

# **Official Transcript of Proceedings**

## **NUCLEAR REGULATORY COMMISSION**

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                          Metallurgy and Reactor Fuels and Thermal-  
                          Hydraulic Phenomena Joint Subcommittee

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

JOINT METALLURGY AND REACTOR FUELS AND THERMAL-

HYDRAULIC PHENOMENA SUBCOMMITTEE

+ + + + +

TUESDAY

MAY 17, 2016

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Subcommittee met at the Nuclear  
Regulatory Commission, Two White Flint North, Room  
T2B1, 11545 Rockville Pike, at 12:32 p.m., Gordon R.  
Skillman, Chairman, presiding.

COMMITTEE MEMBERS:

GORDON R. SKILLMAN, Chairman

DENNIS C. BLEY, Member

MICHAEL L. CORRADINI, Member

JOY REMPE, Member

PETER RICCARDELLA, Member-at-Large

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JOHN W. STETKAR, Member

DESIGNATED FEDERAL OFFICIAL:

DEREK WIDMAYER

ALSO PRESENT:

STEPHEN HAMBRIC, Consultant

WALTER KIRCHNER, Invited Expert

TIMOTHY LUPOLD, NRO

JOSE MARCH-LEUBA, Invited Expert

RICHARD MORANTE, Consultant\*

THOMAS SCARBROUGH, NRO\*

ANDREA D. VALENTINE, Executive Director, ACRS

YUKEN WONG, NRO

SAMIR ZIADA, Consultant\*

\*Present via telephone

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## P R O C E E D I N G S

12:32 p.m.

CHAIRMAN SKILLMAN: Good afternoon. This meeting will now come to order. This is a joint meeting of the Advisory Committee on Reactor Safeguard Subcommittees on Metallurgy and Reactor Fuels and Thermohydraulic Phenomena. I'm Gordon Skillman. I'm a member of the Metallurgy and Reactor Fuels Subcommittee, and I'm chairman of today's meeting.

ACRS members in attendance are Dr. Peter Riccardella, Dr. Michael Corradini, Dr. Joy Rempe, the distinguished John Stetkar, past ACRS Chairman and Dr. Dr. Dennis Bley, the current ACRS Chairman. Derek Widmayer of the ACRS staff is the Designated Federal Official for this meeting.

The purpose of today's meeting is for the NRC staff to discuss the final draft Regulatory Guide 1.20, Comprehensive Vibration Assessment Program, for Reactor Internals During Pre-Operational and Start-up Testing, Revision 4. The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate, and make a recommendation for further consideration by the full Committee.

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1           The rules for participation in today's  
2 meeting were announced as part of the Notice of this  
3 meeting published in the *Federal Register*. Detailed  
4 proceedings for conduct of ACRS meetings was  
5 previously published in the *Federal Register* on  
6 October 1st, 2014.

7           The meeting will be open to the public.  
8 We have no -- we've received no written comments or  
9 requests for time to make oral statements. A  
10 transcript of today's meeting is being kept and will  
11 be made available as stated in the *Federal Register*  
12 notice.

13           Therefore, we request that meeting  
14 participants use the microphones located throughout  
15 the meeting room when addressing the Subcommittee.  
16 Participants should first identify themselves and  
17 then speak with sufficient clarity and volume so that  
18 they can be readily heard.

19           A telephone bridge line has been  
20 established for this meeting. To preclude  
21 interruption of this meeting please mute your  
22 individual telephones and lines during presentations  
23 and the Subcommittee discussion. A separate phone  
24 line is also open for the participation of  
25 contractors to support the NRC staff on this Reg Guide

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1 revision.

2 I want to also recognize that we have two  
3 invited consultants with us today. They are Dr. Jose  
4 March-Leuba and Dr. Walter Kirchner. We welcome  
5 these consultants. At this time I ask that attendees  
6 in the room please silence all cell phones and other  
7 electronic devices that would make noises that would  
8 disrupt the meeting.

9 I remind speakers at the front of the  
10 table to turn on the microphone indicated by the  
11 illuminating green light when speaking, and likewise  
12 to please turn it off when not speaking. We will now  
13 proceed with the meeting, and I call on Tim Lupold,  
14 Branch Chief in the Division of Engineering,  
15 Infrastructure and Advanced Reactors of the Office of  
16 New Reactors, to make introductory remarks. Tim?

17 MR. LUPOLD: Good afternoon. I had to  
18 figure out how to -- which button to push here, the  
19 only one. All right. My name is Tim Lupold. I have  
20 recently become the branch chief in the Mechanical  
21 Engineering Branch in the Office of New Reactors, and  
22 I have the pleasure of addressing you today.

23 I'd like to thank you, the joint  
24 committee here today for asking us to present the  
25 changes that we are making to Regulatory Guide 1.20,

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1 the Comprehensive Vibration Assessment Program for  
2 Reactors Internals During Pre-Operational Start-Up  
3 Testing. This is the revision. It is Revision 4,  
4 and I have with me today two members of my staff, Mr.  
5 Tom Scarbrough and Mr. Yuken Wong, and we also have  
6 Dr. Stephen Hambric from the Pennsylvania State  
7 University.

8 On the line we have Richard Morante of  
9 Brookhaven National Laboratory and Dr. Samir Ziada  
10 from McMaster University in Canada. The revisions  
11 made to Reg Guide 1.20 incorporate many lessons  
12 learned over the years, and so without any real  
13 further ado, I'm going to turn it over to Tom  
14 Scarbrough to start the presentation.

15 MR. SCARBROUGH: I'm Tom Scarbrough.  
16 First, I'd like to --

17 CHAIRMAN SKILLMAN: Light on. Thank you.

18 MR. SCARBROUGH: There you go. I'll try  
19 again. I'm Tom Scarbrough. First, I'd like to  
20 introduce our team. Some of you may know our  
21 consultants and some of you may not. So I thought  
22 I'd take this moment to do that. First, Yuken Wong.  
23 He's the senior mechanical engineer in the Mechanical  
24 Engineering Branch of New Reactors.

25 Yuken's responsible for the evaluation of

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1 reactor internals in new reactors, and has  
2 participated in the ESBWR design certification in  
3 South Texas combined license steam dryer reviews.  
4 I'm also a senior mechanical engineer in the branch.  
5 I participated in the Quad Cities and Dresden steam  
6 dryer failure evaluations, and several of the BWR  
7 extended power updates and ESBWR in South Texas  
8 reviews.

9 Here with us today is Dr. Stephen  
10 Hambric, who is a professor of Acoustics at  
11 Pennsylvania State University. Dr. Hambric has  
12 published over 120 papers in the areas of acoustics  
13 and flow-induced vibration and noise. He is the  
14 associate director of the Penn State Center for  
15 Acoustics and Vibration, and a fellow of the ASME and  
16 Institute for Noise Control Engineering.

17 Dr. Hambric has provided technical  
18 assistance to the NRC review of all of the BWR  
19 extended power updates since the Quad Cities steam  
20 dryer failures, and the ESBWR steam dryer design  
21 certification application.

22 Also, we have Mr. Richard Morante, who is  
23 a principal engineer in the Nuclear Science and  
24 Technology Department of the Brookhaven National  
25 Laboratory. Mr. Morante has 25 years of experience

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1 in providing technical assistance to NRC for static  
2 and dynamic structural analysis, vibration and stress  
3 evaluations and numerous other engineering areas.

4 Mr. Morante has participated in the ESBWR  
5 steam dryer design certification review, specifically  
6 the evaluation and resolution of General Electric  
7 Hitachi's fatigue analysis procedures. Also on the  
8 phone is Dr. Samir Ziada, who is a professor of  
9 Mechanical Engineering at McMaster University in  
10 Hamilton, Ontario Canada.

11 Dr. Ziada has published over 200 papers  
12 in the areas of flow-induced vibration and industrial  
13 arrow acoustics. Dr. Ziada has participated in the  
14 NRC review of all of the EPU applications, the South  
15 Texas combined license and the ESAPWR and ESBWR  
16 design certification applications.

17 So first, next slide please. Thank you.  
18 Just trying to give you a brief overview of our  
19 agenda. We're going to talk about the Regulatory  
20 Guide 1.20 and what its purpose is, the reasons for  
21 Revision 4, the summary of those revisions, the  
22 specific lessons learned that we've included in  
23 Revision 4, the public comments received and our  
24 responses, and a summary and conclusion statement.

25 Okay, next slide. Overall, the Reg Guide

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1 1.20 has several applicable regulations at 10 C.F.R.  
2 Part 50, Appendix A, DDC-1, which is quality  
3 standards; DDC-4, which is environmental conditions  
4 and Appendix B regarding quality assurance.

5 As you know, the BWR steam dryer is not  
6 classified as safety-related in the classic sense,  
7 but it serves an important safety function to  
8 maintain its structure integrity and not generate any  
9 loose parts as we've had that happen before in the  
10 past. Regulatory Guide 1.20 provides guidance on  
11 acceptable methods for developing and implementing a  
12 comprehensive vibration assessment program, which I  
13 refer to as CVAP for reactor internals at nuclear  
14 power plants.

15 Particular attention is given to the  
16 avoidance of adverse effects from flow-induced  
17 vibration, FIV, acoustic-induced vibration, AIV, and  
18 mechanically-induced vibration, MIV. We're going to  
19 talk about those particular flow-induced vibration  
20 effects, those vibration effects later in the  
21 presentation.

22 CHAIRMAN SKILLMAN: Tom, let me ask when  
23 --

24 MR. SCARBROUGH: Sure.

25 CHAIRMAN SKILLMAN: When is the right

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1 time for the members to ask specific questions about  
2 the emerging guide, because some of the comments I  
3 have actually are affected by the words that you just  
4 spoke, but I don't want to be premature in asking my  
5 questions?

6 MR. SCARBROUGH: Why don't -- why don't  
7 we -- let me get through the sort of general  
8 introductory and Dr. Hambric will take over, and that  
9 might be the appropriate time to ask those questions.

10 CHAIRMAN SKILLMAN: Okay, okay. Thank  
11 you.

12 MR. SCARBROUGH: Thank you. Standard  
13 review plan 3.9.2 is undergoing revision to be  
14 consistent with Revision 4 to the Reg Guide 1.20. In  
15 terms of the Reg Guide 1.20 overall, it provides  
16 guidance in sort of three main areas: the  
17 classification of reactor internals, prototypes or  
18 limited prototypes or non-prototypes.

19 It talks about multi-unit plants,  
20 individual component replacement, the analysis  
21 procedures, the 14 functions, response modeling,  
22 convergence of the stress calculations and  
23 benchmarking, and then also guidance in measurement  
24 procedures and in-plant measurement issues we've had.

25 The reasons for the revision of the Reg

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1 Guide 1.20, Revision 3 we updated in 2007, and it  
2 incorporated the Quad Cities and Dresden lessons  
3 learned, and also the Vermont Yankee EPU start-up and  
4 the actions taken to address their dryer.

5 Prior to that, the earlier version Rev 2  
6 was a 1976 revision. So there's 30 years of lessons  
7 learned that we pulled in. But when we were working  
8 on Revision 3, there were several areas that we saw  
9 that needed to be further updated. One was the  
10 prototype definitions. There were eight different  
11 classifications of prototype definitions in Revision  
12 3, and that carried over from the earlier revisions.

13 It was very confusing at the time. I was  
14 involved with that Revision 3. We just didn't want  
15 to tackle that problem. That was bigger than we had  
16 time for at the time. So we took this opportunity  
17 with Revision 4 to condense those classifications  
18 down from eight to three, and I think you'll find  
19 they're much more understandable.

20 We've reorganized the Reg Guide in the  
21 various sections to make them more concise and  
22 useful. We've added numerous lessons learned because  
23 of all the activities that have occurred since  
24 Revision 3. The BWR extended power uprate  
25 applications, there have been several of those since

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1       then.

2                   The ESBWR design certification, that  
3       whole issue with the steam dryer. Also South Texas  
4       with the ABWR. We have lessons learned there as well.  
5       We also wanted to pull in the applicability of small  
6       modular reactor applications. For example, the  
7       control rod drive mechanisms may be more inside the  
8       reactor vessel, there being more interaction with  
9       those reactor internals than previously with the  
10      large reactors.

11                  A lot of that is proprietary, because  
12      we're just now starting to look at some of these  
13      smaller reactor designs. But suffice to say  
14      everything's much more condensed in terms of what --  
15      where things could be affected by vibration. In the  
16      next slide --

17                  MEMBER CORRADINI: So can I stop you  
18      there?

19                  MR. SCARBROUGH: Sure.

20                  MEMBER CORRADINI: So what I think I just  
21      heard, just to make sure is basically bringing the  
22      guide up to speed relative to the practices that  
23      applicants have provided to the staff, and the  
24      staff's review of those applications, to make things  
25      a bit more regularized. Is that a fair way of saying

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1 it?

2 MR. SCARBROUGH: Yes sir, yes sir.

3 MEMBER CORRADINI: Okay. The only thing  
4 I didn't understand is the last statement you made  
5 about the CRDs for the small modular reactors. Is  
6 there something particular there that starts concern  
7 with you all or a different methodology that you want  
8 to modify the Reg Guide for that, or are you just  
9 anticipating something?

10 MR. SCARBROUGH: We're trying to  
11 anticipate that. We wanted to alert applicants and  
12 licensees that when they start thinking about  
13 potential vibration effects on reactor internals for  
14 SMRs, there may be a lot more internals that are  
15 involved than previously involved, you know. In the  
16 past, the CRDMs were up, you know, weren't even in  
17 the picture for the evaluation.

18 Here, we wanted to make sure that there  
19 may be additional reactor internals that they may not  
20 be thinking about if they had previously worked with  
21 a large reactor.

22 CHAIRMAN SKILLMAN: Okay. And then so  
23 maybe you're going to answer this later. But so I'm  
24 curious about is there a particular phenomena that  
25 would appear in an SMR that wouldn't appear in current

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1 reactors, and the reason I ask the question is usually  
2 the mass flux is the flow rates are much lower, and  
3 they're usually in natural circulation-driven flows.

4 So I think we're less in a problem, but  
5 maybe there's something about the length and the  
6 spacing that I don't understand. So whenever it's  
7 appropriate, I'd be curious as to what's the  
8 phenomena that's new here that concerns you, or that  
9 might be a concern?

10 MR. SCARBROUGH: Okay. Well what -- we  
11 can get more into that later. What I was thinking  
12 more about was the steam lines and feedback from the  
13 steam lines. Where the lines are smaller, there may  
14 be more -- there may be additional possibility of  
15 more acoustic affects from the steam lines being  
16 smaller lines that come back, and might come back  
17 directly into the reactor vessel. Whereas before, it  
18 would be hitting the steam dryer in the large reactor.  
19 But --

20 CHAIRMAN SKILLMAN: But all the SMR -- oh  
21 wait. Maybe I'm forgetting the design. But all the  
22 SMRs with steam generators, we're talking secondary  
23 side effects. So there's some sort of acoustic  
24 coupling they're worried to the primary system?

25 MR. SCARBROUGH: Yeah. There may be

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1 something that -- coming back that way. We just don't  
2 know yet in terms of all the --

3 MEMBER CORRADINI: Okay, fine.

4 CHAIRMAN SKILLMAN: Building on Dr.  
5 Corradini's question, my thought was the smaller  
6 machines, these smaller reactors are jointly now or  
7 they have lower, smaller diameters probably by  
8 portion lower flow rates, and some lower driving  
9 functions. So my first reaction is I wonder what in  
10 the SMRs they're concerned about.

11 I would think if there's any place where  
12 they will not be a concern it will be in the smaller  
13 machines.

14 MR. SCARBROUGH: Yeah, it might be so.  
15 We didn't want to, you know, ignore those smaller  
16 reactors because of the additional reactor internals  
17 that are involved. Now they may find, based on  
18 analysis, that the flows and such are -- there's not  
19 an issue here. But we didn't want to ignore it and  
20 then have something pop up later. We wanted them to  
21 take a look at it and make sure that there was not an  
22 issue there.

23 CHAIRMAN SKILLMAN: Is the guidance clear  
24 enough that an SMR must have some form of a vessel  
25 model flow test or a monitor test, so that that small

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1 reactor becomes, if you will, a certified prototype?

2 MR. SCARBROUGH: Well, they could follow  
3 the guidance in the Reg Guide, to make sure that it  
4 was a prototype. They did look at this. I know  
5 there's a lot of work going on with the NuScale  
6 reactor. They have a lot of small scale type  
7 evaluations going on.

8 So there may be areas where they can look  
9 at this and look at the Reg Guide, look at the  
10 guidance and say okay, we're going to check this out  
11 and make sure we don't have a potential issue here  
12 with our smaller reactors.

13 So that will be the goal, just to alert  
14 the new vendors that this is an issue for the large  
15 reactors, and make sure that we don't have an issue  
16 occur that we're not anticipating for the smaller  
17 reactors.

18 CHAIRMAN SKILLMAN: Okay. So correct me  
19 if I'm not accurate here. The Reg Guide is really  
20 intended to provide guidance for the NRC staff. It's  
21 used by the vendors. It's used by the manufacturers,  
22 that the true purpose of a Reg Guide is to guide the  
23 regulators in their overview of the product.

24 MR. SCARBROUGH: That's the -- both  
25 actually. It provides guidance for the staff,

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1       because we're going to reference it in 3.9.2, because  
2       we're trying to pull in all of the lessons learned at  
3       the one document. And then also it provides the  
4       guidance for the vendors and such. They know what  
5       the staff is thinking in terms of what the staff would  
6       be asking questions about. So it provides guidance  
7       for actually both groups.

8               CHAIRMAN SKILLMAN: Okay, thank you.

9               MR. WONG: This is Yuken Wong. I just  
10       want to clarify. Revision 3 only addresses light  
11       water reactors. So we want to mention the  
12       applicability to SMR as well.

13              CHAIRMAN SKILLMAN: Thank you.

14              MR. SCARBROUGH: Great, okay. Next  
15       slide.

16              CHAIRMAN SKILLMAN: Just hold, just hold.  
17       (Simultaneous speaking.)

18              MEMBER CORRADINI: We'll wait because  
19       you'll come back.

20              CHAIRMAN SKILLMAN: Go ahead.

21              MR. SCARBROUGH: Okay, thank you. Steam  
22       dryer lessons learned. We've had meetings with ACRS  
23       in the past, and just talked about this in quite a  
24       bit of detail. But the BWR steam dryer lessons  
25       learned, there's been significant improvements in the

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1 evaluation process for this since the picture is the  
2 picture of the Quad Cities Unit 2 in June 2003.

3 Quad Cities Unit 1 had an even larger  
4 break in November of 2003. But we're trying to apply  
5 these lessons learned in the one document, to make  
6 sure everyone understands what the latest lessons  
7 learned are.

8 The second paragraph there has to do with  
9 minor adjustments. As you know, minor adjustments in  
10 geometry and structural properties in conditions can  
11 lead to significant changes. A prime example of that  
12 was the Quad Cities Dresden issues.

13 You would think they would be identical  
14 plants, but their acoustic response to the steam  
15 dryer was significantly different, in terms of how,  
16 and it had to do with how the standard, the safety  
17 relief valves were connected to the main steam lines,  
18 in terms of when the acoustic resonance occurred for  
19 those.

20 Quad Cities unfortunately had to happened  
21 right when they're at 116 percent power or as Dresden,  
22 they passed through it on the way up. So small  
23 changes that you would think not make a difference  
24 can make a big difference in terms of --

25 MEMBER REMPE: So at some point today, I

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1 browsed through the backup slides and your main  
2 slides. But at some point today, I am very interested  
3 in what happened with Peach Bottom Unit 3, based on  
4 the model that was developed using Unit 2 data. So  
5 I would like you to discuss that, because some o f  
6 the text in the Reg Guide seems to pertain to that  
7 example, although it doesn't tell me what happened  
8 and I'm curious.

9 I'll let you decide when to discuss that  
10 later in your presentation. But I just want you to  
11 be aware that I'm interested in that.

12 MR. SCARBROUGH: Thank you. Why don't we  
13 wait? We're going to get through this a little and  
14 then -- and I didn't work on the Peach Bottom one,  
15 but this gentleman did, and so we can talk about that,  
16 okay. All right.

17 MEMBER BLEY: But before you go on, I  
18 want to follow on what Mike and Dick were asking you  
19 about. We learned a lot from the steam dryers on the  
20 BWRs. Have there been other places since then where  
21 what we've learned there has proved valuable, such  
22 that you brought up we're thinking about SMRs and we  
23 want to look there.

24 But I'm just curious if there have been  
25 other areas where we've applied what we learned on

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1 the dryers to other systems?

2 MR. SCARBROUGH: Well you know what's  
3 interesting, a long time ago power Palo Verde had an  
4 issue in their coolant system, in the weather system  
5 in a branch line, and there was a lot of discussion  
6 of what was causing this valve to vibrate downstream  
7 or, you know, in the cooling line.

8 It turned out to be a phenomenon of a  
9 resonance, and now we think back and say well of  
10 course that's what that was. But at the time, there  
11 was a lot of discussion. What is causing this valve  
12 to vibrate itself, and that's what it was.

13 So I think now we have a much quicker  
14 understanding of what can happen with the resonance  
15 and the vibration effects than we did before.

16 MEMBER BLEY: So a place to look for  
17 problems, if something odds comes up?

18 MR. SCARBROUGH: Yes, yes.

19 MEMBER BLEY: Okay, thanks.

20 MR. SCARBROUGH: Okay, so next. I just  
21 wanted to kind of tell you our technical revision  
22 summary has like three main areas, the prototype, the  
23 analysis procedure and measurement procedures. That  
24 was all contained in that slide was.

25 Now the prototype definitions. We've

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1       crunched this down to three definitions, to try to  
2       make it more clear. We have a prototype. It's first  
3       of kind, it's unique and it can be validated and I'll  
4       call it a valid prototype if it's completed, it's  
5       CVAP, what I call CVAP program with no adverse in-  
6       service vibration phenomena, and NRC accepts the  
7       program.

8               So now it's a valid prototype that you  
9       can reference in your analysis. It's a limited  
10      prototype, which would be like the same shape, maybe  
11      a different size, some small differences. But you  
12      could use less instrumentation. Maybe use a smaller  
13      amount of instrumentation on the dryer itself, or use  
14      the main steam line instrumentation that what you've  
15      had to use before.

16             This comes into play a lot of times with  
17      a steam drier for a two unit plant, where you have  
18      one of the dryers is the prototype and the other is  
19      called limited prototype, and that use much reduced  
20      instrumentation just to confirm that in the main  
21      steam lines and such and the dryer are all consistent.  
22      So that's what a limited prototype --

23             MEMBER REMPE: This is the example that  
24      I'm curious about, because again Unit 3 only had  
25      instrumentation on the steam lines, and as opposed to

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1 Unit 2 at Peach Bottom. What happens if you're going  
2 to try and justify it's a limited prototype? You  
3 didn't instrument it.

4 This is based on what's in the Reg Guide  
5 and then something unexpected happens, and I didn't  
6 see that really covered well in the Reg Guide. So  
7 I'm just curious on what happens.

8 MR. SCARBROUGH: But what we -- we could  
9 always clarify that more. The intent was so that if  
10 you do it, if you go down the path of a limited  
11 prototype and you do not, are not able to show which  
12 are instrumentation or less significant  
13 instrumentation, that it's following the same pattern  
14 as the prototype.

15 Then you're -- that's back to a  
16 prototype. You've got to -- now you've got to  
17 instrument it more.

18 MEMBER CORRADINI: So can I state it back  
19 to you. I want to make sure I understand. So who  
20 decides on the definition? The applicant comes in  
21 and says for one I have a Nordic steam dryer and  
22 it's identical to my plant-wise identical to Plant X.  
23 That's a prototype, and the staff would review that  
24 and confirm that they treat it as a prototype?

25 MR. SCARBROUGH: Yeah. First, they could

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1       come in and say you have a prototype. They've already  
2       conducted their CVAP program. It had operating  
3       experience. It was acceptable to the staff.

4               MEMBER CORRADINI: In Plant X and Plant  
5       Y and it's identical?

6               MR. SCARBROUGH: Yes. Now what they  
7       would come in and say we think it's -- we think we  
8       can classify this as a limited prototype because  
9       everything's the same. The steam lines are all the  
10      same. The construction was all the same, you know.

11              MEMBER CORRADINI: So that's the  
12      difference between a limited prototype and a  
13      prototype? That's what I'm struggling with.

14              MR. SCARBROUGH: A limited prototype, you  
15      could put instrumentation in the steam lines, and not  
16      instrument the dryer at all.

17              MEMBER CORRADINI: I understand what you  
18      do. I'm asking how do I know it's under the first  
19      bullet versus the second bullet?

20              MR. SCARBROUGH: The applicant would come  
21      in in their application and describe the differences,  
22      right, and the similarities, and justify that yes,  
23      it's very similar and the staff would say yeah, we  
24      agree. You could classify this as a limited prototype  
25      because of all of the similarities.

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1 But it's applicant's decision to classify  
2 it that way. So now they're going to instrument it  
3 in a reduced fashion.

4 MR. LUPOLD: So but Tom, it's a -- it's  
5 a prototype when it's the first time it's used, right?

6 MR. SCARBROUGH: It's a prototype -- the  
7 prototype is the one that can perform all these  
8 limitations and you validate its performance, right.  
9 Now you have another steam dryer let's say that's  
10 very similar; it's in a very similar system --

11 MR. LUPOLD: And that will either be then  
12 a limited prototype because it's the second in the  
13 series?

14 MR. SCARBROUGH: Right.

15 MR. LUPOLD: Or it could even be a non-  
16 prototype?

17 MR. SCARBROUGH: It could, it could.

18 MR. LUPOLD: If your system's exactly the  
19 same, your dryer's exactly the same.

20 MR. SCARBROUGH: It could, it could. Now  
21 --

22 MR. LUPOLD: I think to answer your  
23 question as the prototype is when it's used the first  
24 time. Okay.

25 (Simultaneous speaking.)

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1 MR. LUPOLD: Do I have that correctly? A  
2 prototype is when it's used the first time.

3 MR. SCARBROUGH: The first time.

4 MR. LUPOLD: I'm in Plant X. I'm using  
5 dryer A and it's a prototype. Now I'm in Plant Y,  
6 I'm using dryer A. It's a limited prototype or is it  
7 just another prototype?

8 MEMBER REMPE: It's a limited prototype.

9 MR. SCARBROUGH: It depends.

10 DR. HAMBRIC: So if I may, on the second  
11 bullet there are differences between the prototype  
12 and limited prototype, but you have to prove those  
13 differences have no impact.

14 MR. SCARBROUGH: Well truly there's no  
15 difference. They're cookie cutter, they're the same.

16 MEMBER STETKAR: What I think they're  
17 asking is I forgot your alphabet soup. Plant X -- X  
18 and A is a prototype because it has never, that  
19 combination has never been used before, okay?

20 MR. SCARBROUGH: Yes.

21 MEMBER STETKAR: Now Y and A, one would  
22 normally think would be a limited prototype. But  
23 from what I'm hearing from you is there might be some  
24 conditions where Y and A could be characterized as a  
25 prototype. Is that correct?

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1 MR. SCARBROUGH: That's correct.

2 MEMBER STETKAR: Okay. What are those  
3 conditions?

4 MR. SCARBROUGH: For example, let's say  
5 they came in and they said it's an identical plant,  
6 but we built our steam lines differently. How we  
7 connected the safety relief valves are completely  
8 different. You know, in one set they're eight feet  
9 long, in one set they're four feet long, the lines.  
10 So the performance is going to be different.

11 MEMBER CORRADINI: Okay, that I get. So  
12 let me tell you why I'm asking the question. When  
13 I'm asking questions, if I'm an applicant I'm still  
14 confused, unless there's more clarity, because I'm  
15 not sure what I come in with. If I was an applicant  
16 I'd say you know, that's limited.

17 And you say well, the steam line's one  
18 foot off to the left and this thickness is a quarter  
19 inch bigger or smaller. No, it's not limited. It's  
20 a non-prototype. You've got to start all over again.  
21 I'm sensing still vagary in here, which is okay as  
22 long as we're clear about that it's vague.

23 CHAIRMAN SKILLMAN: Well, let me jump in.  
24 I'm not okay with it, and here's why. In your  
25 document on page ten, you make clear that after the

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1 prototype has been run through the ringer and shown  
2 to be acceptable through the CVAP, it is now anointed  
3 as a valid prototype. Okay, in other words, it is  
4 the article. It is the reference.

5 MR. SCARBROUGH: Right, okay.

6 CHAIRMAN SKILLMAN: On your third bullet,  
7 it says "non-prototype," and it says by golly, it's  
8 the same as the valid prototype. My view is what's  
9 missing is the clarity of what is a valid prototype  
10 and what is a replica valid prototype. I'm confused  
11 like Dr. Corradini is confused. I can be educated.

12 I can figure it out, but in my view, it's  
13 obscure and in this case words matter. Let me go one  
14 step further so that you can see what I'm confused  
15 with. On pages 9, 12, 38, 40 and 42, you use the  
16 words "internals important to safety."

17 For my 50 years of nuclear, every  
18 internals is important to safety. None are not  
19 important to safety. Now I can get carried away in  
20 Reg Guide 1.26. I can get carried way in quality  
21 classifications. But at the end of the day, anything  
22 that's bolted inside that reactor vessel has a safety  
23 importance.

24 We can say well, we're really over into  
25 witness into that kind of a definition. But I think

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1 the copious words used on those pages, internals  
2 important to safety, combined with what's a  
3 prototype, what's a limited prototype and what's a  
4 non-prototype, is confusing.

5 MEMBER CORRADINI: And so just so to --  
6 excuse me, just apply a line. I looked at the  
7 comments and there were two individuals that had like  
8 95 percent of the comments, and the sense of it is  
9 that they were confused.

10 So that's where I'm -- which is to say if  
11 the real process is I come in and it's not first of  
12 a kind, clearly not first of a kind. Therefore, it's  
13 not a prototype.

14 Now I have to decide is it limited or  
15 not, and I'm coming in in Plant Y with steam dryer A.  
16 If I come in, it strikes me, hearing this discussion,  
17 a better have a discussion with the staff before I  
18 start making a claim that it's under Bullet 2 or  
19 Bullet 3, because it could be either.

20 MR. SCARBROUGH: That's correct.

21 MEMBER CORRADINI: Correct, okay. Does  
22 that provide clarity to what's happening?

23 MR. SCARBROUGH: That's really the  
24 message that we're actually trying to make, is that  
25 it's not a simple decision as to when you come in and

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1       you -- you're pointing to another plant, can you call  
2       your steam dryer a prototype or limited prototype or  
3       non-prototype? What should you call it? It's not a  
4       simple question. That's why we're sending -- really  
5       getting that message across.

6               MEMBER RICCARDELLA:     If it's a non-  
7       prototype, then you don't have to do anything, any  
8       testing or any instrumentation?

9               MR. SCARBROUGH:       That is what would  
10       happen, yeah. But that -- I don't think we're quite  
11       there yet until we learn more about what the  
12       differences are. Now the other reactor internals,  
13       yes. I mean but for steam dryer, I don't -- I don't  
14       we're quite there yet.

15               I think typically what you see is for a  
16       dual unit site, they'll have one of the steam dryers  
17       will be their prototype, and the other one will be  
18       their limited prototype, and they'll do a lot less  
19       testing of that.

20               MEMBER CORRADINI:     That goes back to Dr.  
21       Rempe's question about two versus three in PB. We'll  
22       have to get to that.

23               MEMBER REMPE:       Before you leave that  
24       discussion, that you said well okay, if they fail the  
25       limited prototype path, well they'll have to put more

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1 instrumentation on the dryer. My impression from the  
2 EPU's is that licensees aren't going to like having to  
3 go back and put more instrumentation on a dryer after  
4 it's been operated.

5 I mean when you put the replacement in,  
6 you can put the instrumentation on. But to go back  
7 and put more instrumentation on after it's operated?  
8 Has anyone done that?

9 MR. SCARBROUGH: Yeah. Actually, when  
10 they did Vermont Yankee, they decided -- because it  
11 was radioactive, they beefed up the dryer itself.  
12 But they put a lot of instrumentation in the main  
13 steam lines.

14 MEMBER REMPE: Yeah, you can put it on  
15 the lines --

16 MR. SCARBROUGH: Exactly, right. They  
17 did that.

18 MEMBER REMPE: --and they did that with  
19 Unit 3, but it's not so easy to go back and say well  
20 okay, I'll put some more instrumentation on the  
21 radioactive dryers. No.

22 MR. SCARBROUGH: That's why it's very  
23 important up front to decide, I mean are your two  
24 units identical, you know because --

25 MEMBER REMPE: And Peach Bottom wasn't.

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1       There were some small differences and so --

2                   MR. SCARBROUGH:   And we've had lots of  
3       discussions with licensees in terms of are you sure  
4       that they're the same, and you know, Quad Cities, you  
5       know Dresden.   They would look at their steam lines  
6       and their design and convince themselves it's either,  
7       you know a prototype.   Each one might be a prototype  
8       or one can be a limited prototype.

9                   For those cases, they were able to do it.  
10       Now I want to talk about Peach Bottom, but that's in  
11       terms of just that is the challenge that the licensees  
12       have, to make sure that they won't have a failure at  
13       the other unit that they decided was a limited  
14       prototype, and they ended up their steam lines were  
15       so different they had completely different responses  
16       in their steam lines.

17                   MEMBER CORRADINI:   So then a way to ask  
18       the question might be if I'm not under Bullet 1 but  
19       I could be 2 or 3, is there a screening, a technical  
20       screening process that is offered in the Guide, that  
21       helps me decide where I sit?   It would seem to me  
22       there ought to be some first principles or maybe more  
23       complex screening process that says I've fallen to  
24       under two or I've fallen to under three.

25                   Or I'm going to wait for Professor

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1 Hambric to answer this, because I know acoustics is  
2 kind of complicated, because there's small pressure  
3 perturbations where geometry really matters. Or is  
4 there no screening criteria and it really comes to a  
5 discussion? That's what I'm trying to sort out.

6 MR. SCARBROUGH: Right. Well that's a  
7 good -- I think we should go back and look at this  
8 section, and clarify it more right, and then -- and  
9 look at the possibility of putting this in screening  
10 criteria in this section because, you know, we do  
11 want this to be clear, you know.

12 It's going to be a challenge and that  
13 comes across. It's a challenge to decide which group  
14 you're in, right. You know so we went from eight  
15 categories to three, but we still have to make sure  
16 to give them guidance as to what's the best path for  
17 them to take.

18 MEMBER BLEY: So at what point in the  
19 process does the applicant have to convince the staff  
20 that how they've done this make sense before they  
21 actually install the hardware? Where does that  
22 happen?

23 MR. SCARBROUGH: Very early, you know.  
24 When they start thinking about an EPU, they come in  
25 and talk to us. I mean they're just thinking about

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1 it, and they have to decide okay, you know, and before  
2 they come in they've done a lot of thinking about  
3 what should they call these two dryers --

4 MEMBER BLEY: Which means they've done  
5 some analysis or done some testing themselves?

6 MR. SCARBROUGH: And looked at their  
7 steam lines, looked at how the steam lines are set up  
8 and that sort of thing.

9 MEMBER RICCARDELLA: I mean they're all  
10 doing analyses aren't they? So I mean don't you use  
11 your analyses as part of this decision-making  
12 process?

13 MR. SCARBROUGH: Yeah.

14 MEMBER RICCARDELLA: Wouldn't a utility  
15 use their analyses?

16 MR. SCARBROUGH: Right. They probably do  
17 an analyses to look to see what the steam lines and  
18 the shape and see what they have. But also in terms  
19 of just a pure geometry for the two units.

20 MEMBER RICCARDELLA: And the differences  
21 in, you know, limited versus non-prototype would just  
22 be whether you need to do instrumentation to validate  
23 your analyses, right?

24 MR. SCARBROUGH: Right. If they came in,  
25 it would be a challenge for them to come in and say

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1       it's a complete non-prototype and we're not going to  
2       do anything, right? That would be quite a challenge  
3       for a steam dryer.

4               MEMBER RICCARDELLA: We're not going to  
5       do any testing and instrumentation?

6               MR. SCARBROUGH: Yeah, we're not going to  
7       do any. We've just done some analysis and we're done.  
8       That would be a challenge because there's so much  
9       small changes in geometry and such that can make a  
10      difference.

11              But definitely prototype and limited  
12      prototype could come in and say we're going to  
13      instrument this dryer and this other one in the units,  
14      and the units are identical the best we can tell, and  
15      we're going to put instrumentation on the main steam  
16      lines to show that the performance of these two steam  
17      lines are --

18              MEMBER RICCARDELLA: But not on the dryer  
19      itself?

20              MR. SCARBROUGH: Not the dryer itself.

21              MEMBER RICCARDELLA: But then you said  
22      something about well but if it fails that -- I could  
23      fail. It fails because the instrumentation on the  
24      steam line don't match your analysis?

25              MR. SCARBROUGH: Well for example, let's

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1 say that there was something that they -- for the  
2 instrumentation of the steam lines, and they found  
3 severe Quad Cities types of resonances at 150 hertz,  
4 and we know that the Quad Cities dryer failed from  
5 that type of severe.

6 Now something happened in their lines.  
7 There was a branch line they missed or something,  
8 right. And so they've had to go back and say okay,  
9 what do we do now? One, they might even put in like  
10 Quad Cities, put it in the side branches, to cut down  
11 that resonance. There might be something like that  
12 they do, which is what Quad Cities and Dresden ended  
13 up having to do.

14 So but they'd have to go back and look at  
15 -- go back to the drawing board and say okay, what  
16 caused this severe resonance that we didn't think was  
17 going to be there? That's where the limited  
18 prototype.

19 You're just -- you're checking to make  
20 sure that the performance of the steam lines and such  
21 that would affect the dryer are in the same realm as  
22 what your prototype was. That would be your goal.

23 But we will go back and look at these  
24 sections. We want to make sure that they're clear  
25 and revamp these sections.

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1 CHAIRMAN SKILLMAN: Tom, it seems to me  
2 that there is perhaps a larger issue here. The title  
3 of this document is the comprehensive testing for the  
4 internals during start-up. But as you accurately  
5 pointed out, the Palo Verde, it wasn't internals.

6 It was actually a whistle effect on a RHR  
7 line, and that RHR line was moving about three-  
8 quarters of an inch, if you recall. It was actually  
9 swaying, and it was also vibrating the RHR right  
10 fluent system isolation valve, the number one valve  
11 off the system.

12 MR. SCARBROUGH: Right.

13 CHAIRMAN SKILLMAN: But that whole  
14 pendulum was excited and was actually imposing cyclic  
15 fatigue. Is this really aimed at the reactor coolant  
16 system versus the internals? For the boilers, the  
17 dryer is one piece. We're talking a lot of other  
18 pieces in play for this document.

19 MR. SCARBROUGH: That's true.

20 CHAIRMAN SKILLMAN: I'm wondering if, for  
21 instance, as John said, you can have reactor X with  
22 dryer A in reactor Y with dryer A. One's the first  
23 of a kind, it's a prototype. The next is the non-  
24 prototype. It's supposed to be the same but it's  
25 behaving completely differently.

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1 Reason: It has nothing to do with the  
2 dryer. It has everything to do with the whistle  
3 effect on your main steam safety valves or some  
4 peculiar piping arrangement that is causing a rare  
5 effect or some form of acoustical feedback that's  
6 exciting maybe the dryer and maybe the surveillance  
7 and other tubes down in the reactor vessel.

8 So it seems to me that you're really  
9 pointing to a much broader target than just the  
10 internals.

11 MR. SCARBROUGH: Yes, and we do mention  
12 that possibility, that in the sort of background  
13 discussion that there could be other phenomena that  
14 are different types of aspects related to this  
15 phenomena that we're talking about, that's true.

16 CHAIRMAN SKILLMAN: But words matter, and  
17 here we are. We're saying here's this things about  
18 internals and what we're really talking about is  
19 perhaps two absolutely robust, one design of say a  
20 dryer, an RSD replacement steam dryer, extremely  
21 robust. All of us would say boy, that thing's really  
22 fit for duty.

23 Put it in two different plants and in one  
24 plant vibrates, in the second plant it doesn't, and  
25 we say well, it's not the RSD. It's what the rest of

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1 the system is causing the RSD to do. So why isn't  
2 this more broadly focused?

3 MR. SCARBROUGH: Uh-huh, yeah. We could  
4 do that. We could do that. I mean we could -- we  
5 could look at this and see how we make this more broad  
6 in terms of the guidance and information that we're  
7 trying to pass along to the licensees.

8 MEMBER RICCARDELLA: But there's also the  
9 O&M code, the SME operating and maintenance code, and  
10 there's some sort of an interface with that, isn't  
11 there?

12 MR. SCARBROUGH: Typically, in O&M, we're  
13 really looking at operating components, pumps and  
14 valves and snappers (phonetic). We're looking at,  
15 and this is more looking at -- this is actually more  
16 looking at like pre-service testing, evaluation. I  
17 mean this would be more along that lines rather than  
18 --

19 MEMBER RICCARDELLA: For a new plant,  
20 there's an operational vibration, a start-up  
21 vibration test on their piping.

22 MR. SCARBROUGH: Yes, they do.

23 MEMBER RICCARDELLA: What effect, what  
24 governs that? Is that -- is there another Reg Guide  
25 or --

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1 MR. SCARBROUGH: Actually, there's a Reg  
2 Guide. Is it 1.61? But there's start-up, there's  
3 start-up, and actually we've added some of this to  
4 make sure that they look for things like that, because  
5 as you know, it ended up Quad Cities, the bigger  
6 problem of Quad Cities was their safety relief valves  
7 failing because of this acoustic resonance problem.

8 And so we've added some guidance in those  
9 start-up test programs, and so that when they're  
10 starting the plant up and they're monitoring lots of  
11 different aspects of the plant start-up, that they're  
12 looking for vibration effects in some of these lines,  
13 these steam lines for their components.

14 So we've added, we've beefed up some of  
15 those other Reg Guides, that guidance in those areas.

16 MEMBER RICCARDELLA: So then is that the  
17 answer to Dick's questions, is that there are other  
18 Reg Guides that cover the reactor coolant system?

19 MR. SCARBROUGH: There are. There are  
20 places that we add like that. But this is a place  
21 where we actually talk about the phenomenon. We don't  
22 really talk about that. We're just telling them to  
23 go check that. But here actually we're giving them  
24 discussions of what's happening in this, in this Reg  
25 Guide of this phenomenon.

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1           So we have to go back and think about how  
2       we might want to make this a broader discussion of  
3       this phenomenon. I think this is -- it tends to be,  
4       you know, like internals. So I think we have to keep  
5       that in there. But I think we could look at how we  
6       give guidance to the licensees for other areas that  
7       are also covered.

8           Maybe there's a way we could make it more  
9       broad in terms of how overall, but then this is  
10      specifically talking about the reactor internals  
11      portion of it. But in terms of the phenomenon, make  
12      sure that the readers know that the phenomenon is  
13      something that could affect a lot of other  
14      components, rather than just reactor internals.

15           CHAIRMAN SKILLMAN: Well, I guess my  
16      parting shot is words matter, and if you recall when  
17      the Fukushima task force sent out its first  
18      Recommendation 1, its first Recommendation 1 was the  
19      regs are so complicated, it's so hard to work one's  
20      way through them. I'm paraphrasing, but that's kind  
21      of what it said or what was written there.

22           I used to be a user of these reg guides,  
23      and I could recall just straining to try to put the  
24      pieces together, and here is what I'm going to call  
25      a cardinal reg guide for phenomenon that we've

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1 learned in the industry is one that we must be very,  
2 very careful with.

3 It seems that this is an opportunity to  
4 really get this one right. It's more than just the  
5 internals on a boiling water reactor. It is internals  
6 in a P, a big P, a small P, a small P, an SMR and any  
7 other machine that we put together.

8 The phenomenon, the phenomena are  
9 approximately the same, and how we write this, how  
10 this is written can guide users to, if you will, to  
11 get it. And so you know, we've got to be mighty  
12 careful here.

13 MR. SCARBROUGH: Right, right. Our goal  
14 was to take our sort of collective knowledge that we  
15 have of the people working on this problem for many  
16 years, and get it -- get this guidance out to the  
17 staff, who's going to come behind us and the  
18 applicants and the licensees who are going to be using  
19 it.

20 So if there's a way we can make it more  
21 clear and more useful yeah, yeah. I'm all for that.

22 CHAIRMAN SKILLMAN: It just seems like it  
23 has a preponderance of guidance for replacement steam  
24 dryers and boiling water reactors, when in reality,  
25 at least from my perspective, there's a whole lot

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1 more at play than just that, and that's important. I  
2 agree with that, that there's more than that, that is  
3 affected by this revision.

4 MR. SCARBROUGH: Right, right. Okay.  
5 Good, thank you. We'll go back and we'll think about  
6 that and see how we could look at that.

7 CHAIRMAN SKILLMAN: Please take a look at  
8 the term internals important to the safety.

9 MR. SCARBROUGH: Yes. I wrote down the  
10 page numbers. We're going to back --

11 CHAIRMAN SKILLMAN: And I think, at least  
12 I read that. Why is that distinction being made?  
13 Aren't all interanls practically speaking, important  
14 to safety?

15 MR. SCARBROUGH: Yes.

16 CHAIRMAN SKILLMAN: This is not about  
17 quality classification.

18 MR. SCARBROUGH: Right.

19 CHAIRMAN SKILLMAN: It's a broad term. I  
20 think all internals are important to safety.

21 MR. SCARBROUGH: We will do a search on  
22 that term and make sure that it's clear, because I  
23 agree. I think if it's a reactor internal, it's  
24 important to safety for some reason inside the  
25 reactor.

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1                   CHAIRMAN SKILLMAN: Consider where there  
2                   are P's where internals have fallen apart. Not P's,  
3                   P's, and that is a terrible job to retrieve the broken  
4                   pieces. If it's outside the core barrel, then you  
5                   have a double or triple problem because pulling the  
6                   core barrel out probably taller than the fuel pool is  
7                   deep, and you've got some serious radiological issues  
8                   that you've got to contend with to finally get into  
9                   the broken part of the internals. They are normally  
10                  affected by vibration.

11                 MR. SCARBROUGH: Right, right. Great.  
12                 This is all good feedback. Thank you so much. We  
13                 will work on that. So basically that was it for my  
14                 discussion. I'm now going to turn it over to Dr.  
15                 Hambric.

16                 CHAIRMAN SKILLMAN: Steve welcome. Go  
17                 ahead.

18                 MEMBER CORRADINI: So since you're up, I  
19                 want to ask your opinion about the slide we just  
20                 passed. So is there a screening process that is used  
21                 in other industries to decide what is or isn't  
22                 important, or is it really so geometrically dependent  
23                 that it's more a matter of the discussion?

24                 DR. HAMBRIC: I could go back to what  
25                 they do on Navy reactors.

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1 MEMBER CORRADINI: Okay.

2 DR. HAMBRIC: And there it is very  
3 specific --

4 MEMBER CORRADINI: As long as you say it  
5 out loud.

6 DR. HAMBRIC: Sure. There, it's specific  
7 to each application. Every component has its own set  
8 of screening. But any time they change anything,  
9 it's just jumps back to prototype, and they're much  
10 more rigorous than in a commercial nuclear power  
11 plant.

12 We had struggled with exactly the comment  
13 you had. This isn't a steam dryer reg guide. This  
14 is a reactor internals reg guide. We use a lot of  
15 steam dryer examples, because that's where our  
16 lessons learned have come from over the past ten  
17 years.

18 We looked at the prototype, limited  
19 prototype, non-prototype. We didn't want to turn it  
20 into here's how you do it for dryers. We believe it  
21 or not tried to make it more generic than that, and  
22 talked about trying to put a decision tree in there.  
23 It's like how do you do that for every type of reactor  
24 internal?

25 You can't, and we'll go back and think

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1 about it. Maybe there's a generic way we can put  
2 together some things for an applicant to consider,  
3 you know, flow rates and geometric differences and  
4 things like that, drop frequencies on the machinery.  
5 I think we can come up with a few things that we can  
6 put in a decision tree like that.

7 It will be a guideline, and I think we  
8 also went through great pains to put in there several  
9 locations. The staff will evaluate on a case-by-case  
10 basis, because we can't turn this into a spec. So I  
11 don't know if that's a helpful comment or not.

12 MEMBER STETKAR: Well, I think some of  
13 the concerns are that -- you read the history of this  
14 reg guide, that it was 30 years between Rev 2 and 3  
15 I think or something like that. So you have to think  
16 about, regardless of what you say that this is  
17 guidance to the industry; it's guidance to the staff.

18 That's what it's written for, and if  
19 you're walking the staff into a position where you  
20 and I as two responsible reviewers would reach  
21 different conclusions for two different applicants  
22 about the level of rigor that needs to be applied to  
23 them because this is musky and you exist today and I  
24 exist some years from now, then we ought not to do  
25 that.

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1                   We don't need necessarily, you know,  
2                   engineering-specific criteria, which there has to be  
3                   some latitude. But if there's so much latitude that  
4                   they'll be a natural tendency of staff reviewers to  
5                   ratchet people into doing more and more and more,  
6                   that's some of my concern, because it's the easy path  
7                   out for the reviewer and of course, well you know,  
8                   it's always better to have people do more testing and  
9                   put on more instrumentation.

10                  So at least some, if the way you've  
11                  characterized it as guidance, you know, based on  
12                  principles or things that -- where we know that the  
13                  differences may make a difference, to focus people on  
14                  those issues, it might help.

15                  DR. HAMBRIC: Right, right. So this  
16                  slide puts some more definitions behind the new terms  
17                  we've added to the Reg Guide. Before in Rev 3, we  
18                  had the term "FIV," flow-induced vibration, and  
19                  that's really where most of the focus was. I think  
20                  we understand that pretty well, although we're still  
21                  learning things as we proceed with new reactor  
22                  reviews.

23                  But basically the idea is you have fluent  
24                  flow over, across, through some sort of a component,  
25                  and there are certain special flow speeds that

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1 coincide with the dimensions that give you a strong  
2 response. If that also happens to line up with the  
3 resonance, then you've get a big response and a big  
4 excitation. So we call that FIV.

5 But sometimes that response is acoustic  
6 in nature, and that's really what happened in Quad  
7 Cities and is continuing to happen in some reactors  
8 today. You've got that flow resonance, but it's  
9 really a resonance associated with a flow over an  
10 opening and it sort of self-reinforces, it gets  
11 strong.

12 But if you have an acoustic mode next to  
13 that, and maybe another acoustic mode in a pipe next  
14 to that and they happen to be resonating, then you  
15 have an acoustically-induced vibration issue. It's  
16 flow-induced and acoustically-induced, so they're  
17 combined and that's where acoustic pulsation theory  
18 and all of that come into play in an analysis, that  
19 sort of a response.

20 And then it doesn't happen as often, but  
21 we have been spending a lot of time over the past  
22 several years looking at reactor recirculation pump  
23 excitation, and those are strong tones that occur not  
24 only in the drive frequency but more importantly at  
25 the vein passing frequency, the number of impellate

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1 (phonetic) veins multiplied by the drive frequency.

2 When we first started looking at these  
3 dryers, and again this isn't just a dryer reg guide  
4 but we used that as our example, they would acquire  
5 a bunch of data and say oh, we took out this  
6 frequency. Why did you do that? Oh, that's the vein  
7 passing frequency. We don't care about that.

8 MALE SPEAKER: That's the what frequency?

9 DR. HAMBRIC: The vein passing frequency  
10 of the reactor recirculation pump. We don't care  
11 about that, and then we reviewed Susquehanna and were  
12 surprised to see that the first time they had a dryer  
13 failure back on that in the 80's, they blamed it on  
14 a vein passing frequency.

15 So there are plenty of -- the industry's  
16 kind of gone back and forth on that. One of the  
17 comments was it wasn't necessarily a vein passing  
18 frequency. Some of it might have contributed, fine.  
19 Since that point, we've been looking at the pumps  
20 pretty regularly, to make sure that those tones are  
21 accounted for.

22 MEMBER CORRADINI: So let me say it back  
23 to you again so I make sure I got it. The FIV is  
24 flow-induced. So row V squared over some strange  
25 geometry.

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1 DR. HAMBRIC: With a non-linear term in  
2 that "some strange geometry" remark.

3 MEMBER CORRADINI: Sure, sure. The  
4 second bullet, is that coupled with something that's  
5 going at the speed of sound and the unusual geometry  
6 could reinforce? Okay.

7 DR. HAMBRIC: Those frequencies are  
8 identical and they reinforce each other.

9 MEMBER CORRADINI: And they reinforce  
10 each other. The third one is a mechanical piece of  
11 equipment that essentially creates a (sound).

12 DR. HAMBRIC: Faster than that, but yeah.

13 MEMBER CORRADINI: Faster than that, but  
14 something such as that that is essentially the  
15 forcing function that would cause the third bullet?

16 DR. HAMBRIC: Uh-huh.

17 MEMBER CORRADINI: But not interwoven  
18 with acoustic waves or flow? It's just strictly a  
19 propagation of that mechanical vibration through the  
20 system?

21 DR. HAMBRIC: We have worried about the  
22 combination of all three, a fairly recent  
23 application.

24 MEMBER CORRADINI: But the other two  
25 don't have a piece of mechanical equipment. The third

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1 one is clearly some -- you have a forcing function by  
2 a piece of mechanical equipment.

3 MEMBER RICCARDELLA: Yes. You  
4 characterize that as structure boom (phonetic). I  
5 guess I'm --

6 DR. HAMBRIC: It can be both.

7 MEMBER RICCARDELLA: And I thought vein  
8 passing frequencies could be flow formed as well?

9 DR. HAMBRIC: It could be both. But we  
10 call that collatomechanical (phonetic) source and it  
11 can propagate acoustically and structurally. If you  
12 look at the path that it takes to an internal, it's  
13 a lot more tortuous to get there acoustically and  
14 there are a lot more locations along the transmission  
15 path where they can be a really big attenuation, where  
16 structurally it could just get anywhere.

17 MEMBER CORRADINI: But isn't that putting  
18 pressure pulses in the fluid, the vein?

19 DR. HAMBRIC: It is, but it's putting  
20 pressure pulsations in the recirculation fluid, not  
21 necessarily up in the steam lines or into the RPV  
22 acoustic volume or --

23 MEMBER CORRADINI: Ah, okay, okay.

24 DR. HAMBRIC: So we've looked at both and  
25 in fact applicants just go ahead and leave the signal

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1 in their acoustic part, but they also will propagate  
2 the forces through the piping, into the RPV, apply  
3 the forces to the mounts of any internals, see what  
4 the excitation forces are, try to come up with  
5 conservative ways of estimating the response. So  
6 that's become routine now, that they'll assess that  
7 pump MIV excitation.

8 MEMBER RICCARDELLA: That's why you  
9 always make odd numbers of veins isn't it?

10 DR. HAMBRIC: Historically.

11 MEMBER RICCARDELLA: So they interact.  
12 So they -- well, I was going to say so they cancel  
13 each other out.

14 DR. HAMBRIC: Well, it depends on what  
15 inflow you have. So if you've got a bunch of struts  
16 on the inflow and you have an even number of struts,  
17 you want an odd number of spinning blades. So that's  
18 one of the major changes in the Reg Guide, is we now  
19 spell all those pieces out a little more rigorously,  
20 a lot more rigorously.

21 All right. So this is just literally an  
22 outline of the Reg Guide, and these are the headings,  
23 subheadings throughout. This first slide is a block  
24 of analysis procedures. It talks about structural,  
25 hydraulic and acoustical modeling. Three sub-bullets

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1       there, the modes of vibration. That's pretty  
2       important.

3               Structural dampening, also extremely  
4       important. We argue to this day with applicants about  
5       what appropriate dampening levels ought to be, and  
6       then something we call frequency response functions,  
7       you know, how the overall system responds, the  
8       functional frequency to a given drive.

9               And that's actually the easier part. The  
10      hard part is the forcing functions, and we did the  
11      best we could to come up with as an exhaustive list  
12      as we could. But we also stressed in the write-up  
13      that that doesn't guarantee you've caught all of  
14      them. Any new plant, any new internal has to consider  
15      all the potential forcing functions.

16              There may be others besides just the ones  
17      we're listing here. These are just examples. So we  
18      have the flow excitation or the feedback. Several  
19      applicants have used scale model testing to try to  
20      emulate that or simulate that. So we have guidance  
21      on that which we'll get to.

22              CFD, the future may or may not involve a  
23      lot more use of CFD for determining these forcing  
24      functions. So we give guidance on that.

25              MEMBER CORRADINI: So can I stop you

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1       there?

2                   DR. HAMBRIC:   Yeah.

3                   MEMBER CORRADINI:   So I'm in single phase  
4       most of the time, and whether it be a liquid or a  
5       gas, and I'm going to do a CFD.   Where do you believe  
6       it versus wanting to validate it based on some sort  
7       of scale model testing or extrapolation?   That is,  
8       would you, you know what I'm asking?

9                   I'm asking where does the belief stop and  
10       it gets to be I need some sort of scale model testing?  
11       Is it complex geometries?   Is it -- what is the --  
12       when you're presenting something to review, when do  
13       you start doubting what's calculated versus what is  
14       shown to have matched an experiment, or worse tuned  
15       to an experiment and then extrapolated?

16                   I find that -- for me, I find it very  
17       hard.   So that's why I'm curious, particularly a lot  
18       of your examples are single phase examples.   So maybe  
19       there's something there that I don't.

20                   DR. HAMBRIC:   So I understand your  
21       question.   I've made a note of it.   What I'd suggest  
22       we do is go through some of the lessons learned so we  
23       might be in a better position to talk about that.

24                   MEMBER CORRADINI:   Right, thank you.

25                   DR. HAMBRIC:   But that's an excellent

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1 question. Actually, the fourth sub-bullet there is  
2 maybe part of the answer to that question. We've had  
3 applicants fairly recently with PB-2 and PB-3 have to  
4 use inference approaches to back out what the  
5 effective forces actually were when in spite of best  
6 intentions, things go wrong.

7 Analyses weren't right, measurements  
8 give us unexpected results. We have to go to a Plan  
9 B and work with the applicant on making sure it's  
10 constructive and appropriate. And then the RP force  
11 issue. Then there's a section on benchmarking. So  
12 this is also getting to what you're asking. How are  
13 we proving that the procedures are indeed  
14 conservative, and to make the key point here, it's to  
15 make sure the procedures are conservative, not right.

16 So it's perfectly okay to do an analysis  
17 that you know is wrong, but it's conservative, as  
18 long as you can prove that to us. In some cases,  
19 that is much cheaper and easier to do than a full-on  
20 coupled CFD mechanical response, which is  
21 unreasonable to expect of all our applicants.

22 But a very powerful approach to proving  
23 to us things are okay is something we're calling end-  
24 to-end benchmarking. So we'll talk about that in  
25 fair bit of detail. When we first started all this,

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1       there was a lot of piecemeal benchmarking, combined  
2       by SSR and now we've hopefully in the future switched  
3       to end-to-end, just to really give us confidence that  
4       the procedures are conservative.

5               And then -- and even though everything we  
6       have gone through maybe proved to be conservative,  
7       stress convergence is always sort of the last step.  
8       It's hard to prove that with measurements, and so we  
9       talk about ways of making sure that stress  
10      concentrations are properly handled.

11             And then the final issue there is what  
12      are our acceptance criteria? We turn the thing on  
13      and we start measuring things. How do we determine  
14      yes, you're okay versus no, you need to go back and  
15      evaluate more rigorously? And then finally a section  
16      on pre-operational and testing analysis.

17             So oh, and I left one out, a very  
18      important one, how you can make the measurements.  
19      Going into a lot of our reviews over the past several  
20      years, we've had to evaluate a lot of sort of seat of  
21      the pants measurement procedures, and part of that is  
22      because the reg guide did not give a lot of detailed  
23      guidance on that.

24             So we've tried to correct for that, tried  
25      to bring out a lot of in-plant measurement issues

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1 we've discovered over the years, just so that future  
2 applicants and future staff evaluators know what to  
3 look for. Tried to make sure that there's a decent  
4 documentation plan there for instrumentation, power  
5 extension, acceptance criteria, test duration.

6 Finally, in spite of all of these  
7 procedures, there has to be inspections, just to make  
8 sure that there was no whoops somewhere. We give  
9 guidance for what criteria need to be looked at.

10 All right. All of that was for  
11 prototypes, and that's a tall hurdle and there's a  
12 lot of stuff. They have to do their analysis,  
13 measurement, benchmarking. But when it comes to  
14 limited non-prototype, the bar gets lowered quite a  
15 bit.

16 Presumably if either a limited prototype  
17 proven it (a) changes your system, lead to minor  
18 response variations or it's cookie cutter plan. Plan  
19 B is exactly the same as Plan A, subject to whatever  
20 uncertainty stackups we have.

21 So they're much simplified. The analyses  
22 don't have to be as rigorous measurements, much less  
23 instrumentation, in some cases almost not  
24 instrumentation for non-prototype. But in both of  
25 these sections we point out that hey guys, we've been

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1       there before. What you may think is a minor change  
2       may not be. It could lead to some sort of an issue  
3       with FIV, MIV or AIV and we have to look at these  
4       things on a case-by-case basis based on our  
5       experience.

6               CHAIRMAN SKILLMAN: All right, let's back  
7       up. Let's consider that the plant says I really am  
8       what I believe to be a non-prototype, so I don't think  
9       I need to do anything. You say no, not so fast there.  
10      You really do, and I say I'm following the rules.  
11      Well, where does that leave me? I'm following  
12      regulations. I'm following the guidance, I got it.

13             But since it isn't a regulation, it isn't  
14      required, I say I'm doing what the Reg Guide told me  
15      to do. I'm exactly where John was saying, doing what  
16      I think the Reg Guide guided me to do.

17             I kind of look like them. I've got about  
18      the same flow rate. I've got the same rugged dryer.  
19      I've got virtually the same internals. I've got the  
20      same fuel, I've got the same vein passing frequency  
21      on my recirculation pumps. Why are you making me do  
22      more?

23             DR. HAMBRIC: Well, I think what we would  
24      do -- let me say it again. When they come in and  
25      would say we think this is a non-prototype, we go

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1 through all the things you've just talked about. But  
2 we'd also talk about what about your steam lines.  
3 Are your steam lines identical in terms of how they  
4 were constructed?

5 Were the branch lines all attached in the  
6 exact same fashion as the other plant, and all of  
7 these questions. If they can come back and they can  
8 show that yes, it's exactly the same. It was like  
9 you couldn't be more exact, then we'd say yeah, you're  
10 right.

11 We can't find anything. Everything's the  
12 same. You have the same contractors, the same, you  
13 know, builders came in and built these steam lines  
14 exactly the same way. They used the same technique  
15 of welding the steam line, the branch lines onto the  
16 steam lines. Everything's identical.

17 We'd say yeah, we can't find anything  
18 that's different, right. But so far, because every  
19 plant out there in the United States is built a little  
20 differently, that's a hard thing to prove. Now what  
21 we might do is we might say yeah, we don't -- we're  
22 not quite there, non-prototype.

23 But we think this is a pretty clear case  
24 of a limited prototype, and if you can show that your  
25 steam lines perform in a similar or at least less

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1 resonance phenomenon than your prototype, yeah we're  
2 calling this a limited prototype.

3 CHAIRMAN SKILLMAN: But I won't know that  
4 until I operate the plant.

5 DR. HAMBRIC: For, for, for, this is for  
6 EPU. Yes, you would have to do an EPU. You know, if  
7 it was an EPU, you'd be operating the plant. You  
8 could put those steam lines in as they were operating  
9 and show that it's very quiet, because you can see  
10 that now with Quad Cities and Dresden.

11 Whereas before you saw these significant  
12 peaks in terms on their main steam lines, and after  
13 they put in their acoustic side branches, they were  
14 like flat. There was like nothing going on. So you  
15 can see it and that sort of thing. So you may be  
16 able to from the plant operating, if it's an operating  
17 plant, that it's that way.

18 Now for -- now what we've done with the  
19 ESBWR design certification, there's an ITAAC that  
20 says that once you build the plant and you -- they're  
21 going to do a Struhold (phonetic) analysis to show  
22 that, and they're going to build it the very best  
23 possible way to show that there's no sheer issues  
24 going on with these -- with the main steam lines,  
25 right, and they have ITAAC to demonstrate that once

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1       they start the plant up and start running steam  
2       through, that they would demonstrate that they have  
3       -- that the phenomenon is -- there is no acoustic  
4       resonance that's occurring in those steam lines.

5               So they could do it that way, and then if  
6       they show that there isn't any, the next plant, like  
7       first would be Fermi and then the next one would be  
8       another plant, they could say yes, we've done the  
9       exact same thing as we did with Fermi 3, and we're  
10      going to build it the same way and we're going to do  
11      the same analysis the same way, and we think that  
12      would be a non-prototype.

13             So I think at that point we would say  
14      yeah, we probably can go along with that, right. But  
15      right now with the current fleet of U.S. operating  
16      plants, they always seem to have some, at least some  
17      differences in terms of how the plants were  
18      constructed, because it's a long period of time and  
19      there are so many different things that can happen  
20      over that time.

21             But that's -- it would be a discussion.  
22      They would come in and say this is what we think, and  
23      this is typically what happens with EPU's right now.  
24      They come in and they say this is what we think, and  
25      when we think about it, we gave them some questions

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1 and such and they go back and think about it.

2 And sometimes they come in right off the  
3 batt and they'll say we're going to do this, because  
4 we just think that's a more conservative, safe way to  
5 go and, you know, that's -- it's usually a discussion  
6 we have back and forth with them, to come with some  
7 agreement as to what's the best most efficient and  
8 effective way to try to accommodate the guidance in  
9 the Reg Guide.

10 MEMBER CORRADINI: So might I ask a  
11 little bit different question, but if you need to go  
12 on, you can hold me on. Where you may get a point of  
13 telling us that this is not just for dryers, and you  
14 try to be general, but all your examples come back to  
15 dryers.

16 So then from a technical standpoint, is  
17 it essentially just the combination of the pressure  
18 and the high velocities that drive me to that,  
19 combined with essentially the dryers in terms of  
20 robustness, in terms of rigidity of the structure?

21 They tend to be on the outlying region  
22 and there's other pieces of internals that we would  
23 worry about or could worry about, but they just don't  
24 see the forced velocities, the inertial effects and  
25 are much more robust in size. You keep on coming

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1 back to these examples, and they all tend to be the  
2 same structures. So what is it? Is it strictly that,  
3 those characteristics?

4 DR. HAMBRIC: We had other examples, but  
5 getting back to your comment, this was an internals  
6 thing. So SONGS is a prime example, right. Something  
7 bad happened there, there was a surprise in flow-  
8 induced vibration, fatigue, rubbing. We left it out.  
9 I think we're thinking about maybe putting it in a  
10 different reg guide or other guidance somewhere down  
11 the line.

12 But there were a lot of lessons learned  
13 that maybe indirectly made it into here because of  
14 that experience. We don't call it out, because of  
15 SONGS we did this. But we thought about it. I guess  
16 another area we thought about but didn't include a  
17 specific example is the drawback on the 362, and  
18 that's the LOCA issue and what happens if you have a  
19 jet coming out of a break that's impinging on nearby  
20 structure.

21 You've got a lock in there too sometimes.  
22 So some of the CFD stuff and forcing function stuff  
23 that run up in here, that came from lessons learned  
24 about that. So the industry came up with some clever  
25 ways to do a conservative assessment. It wasn't

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1 right, but it was conservative, and we sort of thought  
2 about how to put that in --

3 MEMBER CORRADINI: And this was -- I  
4 remember that we talked about this, but was it within  
5 the context of ESBWR, if memory serves me?

6 DR. HAMBRIC: We had ESBWR. That gave us  
7 some guidance. We also had the ABWR I believe from  
8 AREVA, the EPR, and everybody had sort of different  
9 ways of going about it. But it was a lock-in issue.  
10 Different one, but I think some of the thoughts that  
11 went into the forcing function part were at least  
12 somewhat inspired by that.

13 But we didn't want to call that out as  
14 the example. So the example that we could call out  
15 was, you know, the dryer experience.

16 MEMBER CORRADINI: Okay, thank you.

17 DR. HAMBRIC: And if we had one, we  
18 certainly put them in.

19 MEMBER CORRADINI: So again, if you're  
20 coming to it you hold me off. I'm still back with  
21 the long control rod drives in an SMR, and I'm  
22 guessing that high density, much lower velocity. So  
23 the mass flux is lower, but maybe it's just the length  
24 and the robustness of the structures that are leading  
25 you to cough that out?

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1 DR. HAMBRIC: Right. It's never been  
2 done before. I don't know how much detail I can get  
3 into here without getting proprietary.

4 MEMBER CORRADINI: That's fine.

5 DR. HAMBRIC: But you've got long beams  
6 with moving masses on them, varying boundary  
7 conditions, resonances changing depending on their  
8 heights, flows that are coming from Lord knows where.  
9 It hasn't been evaluated, and we certainly haven't  
10 done the calculations ourselves. But until we see  
11 them, it's a concern. We just raise it as a potential  
12 issue, that's all.

13 MEMBER CORRADINI: Okay.

14 DR. HAMBRIC: And it could be when an  
15 application comes in they say hey, the flow rates are  
16 like .01 meters per second. We don't care. Okay,  
17 fine. But until we see that, we don't know.

18 CHAIRMAN SKILLMAN: Since we raised the  
19 question or raised the issue at least in my mind, for  
20 the SONGS steam generator, would the replacement  
21 generators have been a prototype or a limited  
22 prototype or a non-prototype? Just entertain the  
23 thought for a minute, think about it, based on these  
24 definitions.

25 MEMBER RICCARDELLA: And plus there were

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1 two of them, and they behaved extremely different  
2 because of some very, very minor manufacturing  
3 differences, as I understand it. So you know, would  
4 one of them be a prototype and one of them a non-  
5 prototype? That's the thing.

6 (Simultaneous speaking.)

7 MEMBER RICCARDELLA: It seems -- that's  
8 the thing. If we can tie that down, I think we've  
9 got a language we can agree on, as crazy as that  
10 seems. I'm back to words matter. They really do in  
11 a fundamental document like this, I kind of think in  
12 my mind.

13 Okay, we're going to have an RCOL  
14 (phonetic) reference plant and then we're going to  
15 have some SCOLs, and if all the SCOLs are absolutely  
16 100 percent identical down to the millimeter, we're  
17 going to call those limited prototypes?

18 Are they going to be knockoffs of F08K  
19 and if the F08K one well, they're going to be valid  
20 prototypes that don't need anything? It seems to me  
21 that that's what needs to be addressed in these terms.  
22 Does that make sense?

23 DR. HAMBRIC: Yes. We're definitely  
24 going to go back and look at that, and try to make it  
25 more clear.

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1 MEMBER RICCARDELLA: But these  
2 requirements don't apply to steam generators right,  
3 and if there were, I mean if there were such  
4 requirements, hopefully might have been avoided.  
5 They've had some instrumentation in there and it  
6 affected the excessive vibration shortly.

7 DR. HAMBRIC: Right.

8 MEMBER RICCARDELLA: I'm not suggesting  
9 it should be, but I just --

10 (Off mic comments.)

11 CHAIRMAN SKILLMAN: Let me make an admin  
12 comment here just for a second. Dr. Hambric, I  
13 understand you need to exit at 1500 or 3:00 p.m.

14 DR. HAMBRIC: I can squeeze it to 3:15,  
15 but yeah.

16 CHAIRMAN SKILLMAN: Okay. I just wanted  
17 my colleagues to know that you do have a time clock,  
18 and if we want to entertain these questions about CSD  
19 or vibration or FIV or MIV, we should get those on  
20 the table before your exit time.

21 DR. HAMBRIC: Yeah. I've been keeping  
22 pretty good notes here, so that we can come back to  
23 a lot of the questions --

24 CHAIRMAN SKILLMAN: Thank you. Okay,  
25 let's continue.

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1 MALE SPEAKER: And we want to make sure  
2 that we answer the question on Peach Bottom. If you  
3 could answer that before you have to leave. Okay.  
4 Great, thank you.

5 DR. HAMBRIC: We'll get to them as we go  
6 through some of these. So I'm not going to read all  
7 these, but the next big block of slides is a specific  
8 lessons learned, and what we're giving you are the  
9 highlights. There are more, but these are the ones  
10 we thought were the most important, and they address  
11 a lot of the topics we've been talking about.

12 So I'm just going to go to the next slide.  
13 Let me -- before I go through this one, introduce the  
14 theme we use for each of these lessons learned slides.  
15 So up at the top in blue we've got a topic. So this  
16 first one is on excitation mechanisms, and then each  
17 of the bullets on the top are the lessons that we  
18 learned or the observations that we have made, right.

19 So we've got three of them there, and  
20 then the arrows down below are the actions that we  
21 took, right, the modifications we made to the Reg  
22 Guide to address our lessons or observations made.  
23 So that's the procedure, if that makes sense. We  
24 have to go through a couple of them and that will  
25 become clear.

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1 But first is just the important  
2 excitation mechanisms to consider, and in the old Reg  
3 Guide it was all FIV and it was I think okay writing,  
4 but it wasn't terribly well defined. So we wanted to  
5 address that. We also had a lot more operational  
6 experience with the resonances that we've observed on  
7 main steam line valves and elsewhere.

8 And the Susquehanna experience, that hey,  
9 there was an RRP, reactor recirculation pump, vein  
10 pass-through frequency, excitation, that may have  
11 contributed to some fatigue cracking. So each of the  
12 areas down below are the actions we took. So we  
13 started off by introducing the mechanisms more than  
14 a FIV.

15 We added acoustic resonances, AIV, MIV.  
16 We specifically called out to the flow excitation the  
17 oscillation modes, the sheer layer. Samir Ziada's on  
18 the line. He's our expert there. We also pointed  
19 out that you get to resonances in MISVs, which haven't  
20 -- had not been considered previously.

21 The last was just an example. It wasn't  
22 meant to be, you know, something you always have to  
23 look for. But one of the big problems that the steam  
24 dryer community has had in properly capturing the low  
25 frequency vibration and stresses in the skirt. We

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1 kind of looked at the ways they were modeling the  
2 excitation and one important one left out is when you  
3 take skirt, you dunk it in a big bucket of boiling  
4 water.

5 None of that's considered in the forcing  
6 functions, and I don't know how you consider it. But  
7 it has to be addressed somehow, and the way we address  
8 it is via this end-to-end benchmarking approach that  
9 I'll talk about later on. So that's just the example.  
10 It wasn't meant to be a forcing function. You always  
11 had to look forward, just an example of how we were  
12 confronted with a new internal or a dramatically  
13 modified internal.

14 We had to think outside the box and think  
15 about all the possible functions that might influence  
16 you. So any questions on that first slide or how  
17 we're doing it?

18 So now we've got three slides on  
19 structural modeling lessons learned, and the first  
20 one is just looking at modes of vibration, and this  
21 lesson is not a surprise. Anybody that's ever worked  
22 in structural modes and comparing measured mode  
23 shapes to modeled or analytic mode shapes knows that  
24 there are always differences.

25 The frequencies are different between a

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1 measurement and a model. The shapes themselves can  
2 be a little bit different between the measurement and  
3 the model. That's just reality. Those differences  
4 really have to be used to establish an uncertainty in  
5 how you model resonance frequencies.

6 You build a model and you get a  
7 frequency. So you have to realize that that's got a  
8 plus or minus. So the action that we're taking there,  
9 and we've been doing this for over ten years now, is  
10 that any forcing function that's applied to an  
11 internal, to account for the fact that a modeled set  
12 of resonances has uncertainty in it, the forcing  
13 function has to be either compressed.

14 So if you think about a time series,  
15 you've got to make it shorter so the frequencies move  
16 it, or stretch it so that all the frequencies move  
17 down, and have several increments of stretching and  
18 compressing so that you're applying those forcing  
19 functions to your analytic or numerical model.

20 By stretching and compressing, you're  
21 making sure that you're coming up with worse case  
22 combinations of forcing functions and resonance  
23 response. So you're sort of aligning your peak  
24 forcing functions with your peak responses, and  
25 pulling out the worse case response as a conservative

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1 estimate.

2 We just threw in there plus or minus ten  
3 percent. It has been acceptable in past  
4 applications, but that is not a specific acceptance  
5 criterion. It is hey, this is what's worked in the  
6 past. You guys need to tell us that yes, plus or  
7 minus ten percent is okay for your application.

8 It may be that plus or minus 15 percent  
9 is required, depending on their particular structure.  
10 The second action we took is addressing essentially  
11 Peach Bottom, and that's force inference procedures.  
12 So I can try to speak to Peach Bottom without going  
13 proprietary but --

14 MEMBER CORRADINI: This is microphone  
15 analogy, if I remember. I don't want to say too much,  
16 but I'll probably get it wrong, so it can't be  
17 proprietary. But I seem to remember this is the  
18 approach that you explained to us when we were doing  
19 this comparison, in terms of the methodology. Am I  
20 --

21 DR. HAMBRIC: Let me talk it through, and  
22 we'll see if that matches up or not. So (name) is in  
23 the back, and he'll raise his hand if I'm getting  
24 proprietary and stop me. But he was the lead on --  
25 or is still the lead on Peach Bottom, although I think

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1 we've tied it off.

2 In spite of all best intentions,  
3 analyses, measurements, when they turned Peach Bottom  
4 on with the replacement drive and all this nice  
5 instrumentation and measured the strains, they  
6 discovered that the strains were above the acceptance  
7 criteria.

8 After a lot of soul-searching and head  
9 scratching, they came back to us and said you know,  
10 we're not sure why. We think our methodology is  
11 overly conservative. We do not believe this tank of  
12 a drive we just built and installed is really going  
13 to fatigue fail. Let's suggest a different approach  
14 to it.

15 The approach was let's use all of our  
16 strain measurements on the dryer. These are measured  
17 strengths now, and combine them with numerically  
18 computed mode shapes for the model.

19 MEMBER BLEY: I'm sorry. Numerically  
20 computed what?

21 DR. HAMBRIC: Mode shapes.

22 MEMBER BLEY: Mode shapes.

23 DR. HAMBRIC: Right. So we've got a  
24 model. We've extracted the mode shapes. We know how  
25 this structure is vibrating. We know where all the

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1 peak strains are, we know where all the peak stresses  
2 are. But mode shape is just a mode shape. There's  
3 no amplitude associated with it. It's arbitrary.  
4 It's just here's how it vibrates.

5 Where do we use these strain  
6 measurements, and there's a lot of them? Attach them  
7 to the mode shape and then use those to tell us how  
8 strongly that mode is vibrating, and look at the peak  
9 stress locations and see if we're under or above the  
10 acceptance limit.

11 So they're inferring the stresses based  
12 on measured strains and a numerical model of the mode  
13 shapes, and that's fine, as long as you prove to us  
14 the model converged and the stresses are converged  
15 and all that good stuff. But where we went back and  
16 forth originally is they did not take into account  
17 the fact that the numerical model had uncertainty in  
18 where the resonance frequencies were.

19 There may be a strain at one resonance  
20 frequency in the real dryer, and a strain to a  
21 simulated resonance in a model dryer. But there's no  
22 guarantee that the frequencies are right. Does that  
23 make sense?

24 MEMBER BLEY: No. Say it again please?

25 DR. HAMBRIC: So I've got this bottle.

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1 It has a resonance at 63 hertz. I go off and have  
2 somebody build a model of that bottle. They come  
3 back with that same resonance at 78 hertz, okay. I  
4 take a measured strain at 63 hertz and try to apply  
5 it to the response of the model alt 63 hertz and it's  
6 wrong, because it really should be at 78.

7 They have to account for that  
8 uncertainty. That's all that's saying. So we put  
9 that in a reg guide. You have to account for that in  
10 an inference procedure.

11 MEMBER REMPE: This is all Peach Bottom  
12 2, and now where are they with respect to Peach Bottom  
13 3 that only has instrumentation on the steam lines,  
14 because it was believed to be a limited prototype,  
15 and I again, when we recruit the EPU, it was all in  
16 the future. So I'm curious on what's happening? Have  
17 they started that, the EPU at Peach Bottom?

18 DR. HAMBRIC: Oh yeah. That's all been  
19 done. So what they had to do is they were going to  
20 instrument Peach Bottom, the second one. I always  
21 get them mixed up, which one came first. They were  
22 going to instrument the second one. It was too late.

23 MEMBER REMPE: It was 3.

24 DR. HAMBRIC: Three. It was already in  
25 there. So what we had to do was make a link between

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1 the measurements that we're going to make, which was  
2 the main steam line measurements, which is pretty  
3 typical, and what happened on the dryer in Unit 2,  
4 the first dryer.

5 So we had to go through a lot of  
6 statistical correlation studies, looking at sensors  
7 in the dryer versus what happened in the main steam  
8 lines and the first instrumented prototype, and then  
9 come up with a correlation analysis that we thought  
10 was conservative, that we could then apply to the  
11 limited prototype case.

12 MEMBER REMPE: And how is that going with  
13 the data?

14 DR. HAMBRIC: It worked. It was fine.

15 MEMBER REMPE: Okay.

16 DR. HAMBRIC: The other benefit we got  
17 out of that is that we could throw away a lot of the  
18 scale model testing and CFD and other procedures they  
19 use to estimate the SRV resonance amplitude because  
20 we had them measured in the prototype plant, and we  
21 could sort of track them in the second plant and show  
22 that yes indeed, they were following the same arc.

23 There wasn't a big surprise, no big  
24 amplification. Everything was okay. So because  
25 they're able to make that link between the

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1 measurements that we're going to make and the  
2 prototype measurements, we were allowed to -- we felt  
3 we were reasonably assured we could proceed with the  
4 limited prototype assessment on the second drive.

5 MEMBER BLEY: Let me sneak a question in.  
6 You said we could throw away the CFD and some other  
7 things.

8 DR. HAMBRIC: Yeah, because we had in-  
9 plant measurements at that point.

10 MEMBER BLEY: But did they -- had they  
11 actually done the CFD? When you say "throw away" --

12 DR. HAMBRIC: It was a very limited CFD  
13 just to -- and then I only get proprietary --

14 MEMBER BLEY: I was kind of hoping there  
15 was more ---

16 (Simultaneous speaking.)

17 MEMBER BLEY: --as to how it matched up.

18 DR. HAMBRIC: No. Most of what they used  
19 to estimate the SRV amplitudes was scale model  
20 testing, which is another big topic that we'll get  
21 to.

22 MEMBER BLEY: Okay yeah, thank you.

23 DR. HAMBRIC: CFD was more about what are  
24 the flow rates, what are the Struhold numbers, just  
25 basic screening stuff. But it was not rigorous by

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1 any means. Don't know if I fully answered your  
2 question or addressed your concern.

3 MEMBER REMPE: Maybe I missed it, because  
4 this is not my area. But when I was reading through  
5 the Reg Guide, I would not have gotten that there's  
6 a way around if you go the limited prototype  
7 methodology and things just didn't work out the way  
8 you planned, and there seems to be another path  
9 through it all is what I'm getting from this  
10 discussion.

11 I didn't get that from reading the Reg  
12 Guide, and I mean it's much easier in life than saying  
13 well, you've got to put some more sensors on, as I  
14 heard at the beginning of the discussion today. I'm  
15 just wondering did I miss it and it's really in this  
16 Reg Guide, or is there some additional --

17 And I know you're talking about  
18 proprietary stuff. But are there some additional  
19 clues you can give people in the future?

20 DR. HAMBRIC: We could. We added some  
21 vague discussion.

22 MEMBER REMPE: And it was vague enough I  
23 missed it, okay.

24 DR. HAMBRIC: But we didn't want to get  
25 too detailed about this particular application

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1       either. But we could go back and think about maybe  
2       beefing that up a little bit, trying to make a general  
3       guess.

4               MEMBER BLEY: I think that's fine. I've  
5       been interested in this. I'm learning a lot listening  
6       to you today for me too. It's not my area, although  
7       the analog over in electrical was once my area. But  
8       that's been a long time ago.

9               I know we've written letters that touched  
10       on many of the things that are in here in the past,  
11       and I was kind of hoping when this was done, one of  
12       the reasons I wanted us to review it is so we could  
13       make sure things were in here that we might ask about,  
14       that it's covered in the Reg Guide.

15              And as I read it, being a bit of a  
16       neophyte to the words, it seemed like it gave general  
17       coverage to everything that might be important, but  
18       it was pretty darn general. My question is, as a Reg  
19       Guide, is it too general? Now this is what you were  
20       just talking about.

21              Is it too general for an applicant, and  
22       for a reviewer, I think it's got the things a reviewer  
23       could start digging in and say did you do this? Did  
24       they face this enough.

25              But it's also a reg guide that the

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1 applicants and licensees would use, and is it  
2 thorough enough to make sure they think of all the  
3 things they should be thinking about? I don't know  
4 the answer to that. I'm just wondering.

5 DR. HAMBRIC: Well, we tried but I'm sure  
6 we missed some things. But I can appreciate some  
7 generic guidance on, you know, a lessons learned for  
8 how we handled the Peach Bottom situation when  
9 despite best intentions, instrumentation didn't work  
10 out. It was too late to add more instrumentation.  
11 How did we make it work out anyway, in a fashion that  
12 gave us reasonable assurance that things were okay?

13 CHAIRMAN SKILLMAN: Steve, before you go  
14 on, let's go back to 16 just for a second. When I  
15 envision these gauges that are on the dryer, I see  
16 these small devices that are fixed, and in a past  
17 life I lived we had a very difficult time assuring  
18 that the strain gauge remained fixed and the effect  
19 that we were sensing on the strain gauge was truly  
20 the effect of the device that we were monitoring  
21 versus the effect of the physical phenomena,  
22 temperature, pressure, evaporation rate on the strain  
23 gauge itself.

24 So here is a particularly complicated  
25 welded structure that is seeing wetting and mount

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1 wetting and other oscillating modes, whether they are  
2 acoustic, whether they are mechanical, whether they  
3 are thermohydraulic. How does one discern the  
4 difference between the effect on the strain gauge and  
5 the effect upon the component to which the strain  
6 gauge is affixed?

7 DR. HAMBRIC: All right. So we have in  
8 the measurement section some discussion on strain  
9 gauges. It would not completely answer your  
10 question, but it might be a good point to poke it out  
11 a little bit further.

12 CHAIRMAN SKILLMAN: Okay.

13 DR. HAMBRIC: We can wait until we get to  
14 that.

15 CHAIRMAN SKILLMAN: I'll wait. Yes, I'll  
16 wait. Thank you.

17 DR. HAMBRIC: All right.

18 MR. HAMBRIC: So, this is Slide 2 out of  
19 3 for structural modeling. The last one was modes,  
20 this one is damping. This has a lot of history to  
21 it, but a lot of applicants still use a time-domain  
22 analysis approach, instead of a frequency-domain  
23 approach. And, historically, that means something  
24 called Rayleigh damping. And for those of you who  
25 are not familiar with that, you pick a low frequency

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1 anchor point, a high frequency anchor point, and you  
2 set the damping at those frequencies.

3 The issue is what happens away from those  
4 frequencies. And what you get is almost like a  
5 parabola, not quite. But at the anchor frequencies,  
6 the damping is exactly what you specify. In between,  
7 it's lower, and that's conservative, it means more  
8 vibration response predicted, higher strains and  
9 stresses, so that's fine. But outside those anchor  
10 frequencies, the damping is too high and is not  
11 conservative. So, we have seen applicants set their  
12 anchor frequencies and have a really strong  
13 excitation below that anchor frequency, meaning that  
14 they've got a structural response that's non-  
15 conservatively to damped. Or the opposite, they've  
16 got a forcing function that's above the high  
17 frequency anchor point, meaning they're applying a  
18 load to the structure and they're putting too much  
19 damping on the structure.

20 So, we've spelled it out, hey guys, when  
21 you've got forcing functions, you need to look at  
22 those forcing functions and make sure your anchor  
23 frequencies bracket them. I think that's pretty  
24 obvious. We also are always getting push-back from  
25 industry, we've put in the guidances that one percent

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1       damping has been acceptable in the past. And that  
2       one percent encompasses pretty much everything, it's  
3       the structural damping, it's the damping you get when  
4       you mount a structure in a system and you've got  
5       interface damping, it's the fact that you're in a  
6       steam environment with radiation damping. It's meant  
7       to cover the as-installed damping conditions. We  
8       said one percent is a conservative number you can  
9       use.

10               Some applications have said, hey, we know  
11       in this particular structure, in this case a steam  
12       dryer, we have other components inside the dryer that  
13       have higher damping, and the one in particular is a  
14       perforated plate that the steam goes through. And as  
15       the plate vibrates and the steam pushes back and forth  
16       through the holes, you get viscous effects, that's  
17       higher damping. And they said, hey, let us claim an  
18       extra damping for that. We put that as an example in  
19       the Reg Guide that that's fine if you substantiate  
20       and validate it, and previous applicants have done  
21       that.

22               MEMBER RICCARDELLA: By test or by  
23       analysis?

24               MR. HAMBRIC: Both.

25               MEMBER RICCARDELLA: By test?

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1 MR. HAMBRIC: They've done a simple test  
2 with a perforated plate, pushed it through air,  
3 measured the damping. Done an analytical study to  
4 show that they can calculate it. Made sure --

5 MEMBER RICCARDELLA: Okay.

6 MR. HAMBRIC: -- that the analytical study  
7 was conservative and applied a conservative added  
8 damping level to their structure. So that's kind of  
9 a success story that we put in there. Next. And  
10 final --

11 MEMBER RICCARDELLA: And percent, that's  
12 percent of critical damping, right?

13 MR. HAMBRIC: Yes, or -- yes. They always  
14 have to report it as percent as critical, but they  
15 can compute it as viscous or hysteretic, but it has  
16 to be converted back over to percent critical.

17 MEMBER RICCARDELLA: Okay.

18 MR. HAMBRIC: Okay. A couple of other  
19 things we've noticed is that some of the early  
20 applications we got were not terribly well  
21 documented, particularly regarding benchmarking, and  
22 that's very important. And also, we've had  
23 applicants come back to us after the fact, during  
24 power ascension, for example, and said, you know,  
25 we've designed this dryer and here's how we analyzed

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1       it and then when it was built, these wells were  
2       different and this structure was different and we  
3       replaced that and made it all better, so they say,  
4       but it was different. And so, we learned that  
5       sometimes there are differences between as-designed  
6       and as-built conditions. And so, the action is that  
7       we need a very formal, rigorous documentation of  
8       procedures and any differences between as-built  
9       versus as-designed structures.

10               This is a single slide on acoustic  
11       modeling. The acoustic models are typically built to  
12       propagate forcing functions from steam line valves,  
13       for instance, or to propagate forcing functions that  
14       come from flow within the RPV itself. If you think  
15       about what's happening to the flow in there, it's  
16       very messy, there's steam kind of being dumped out  
17       and reformulating and sucked into a nozzle, lots of  
18       pressure gradients, turbulence, pulsations that  
19       excite the acoustics inside the entire RPV.

20               And we noticed in a lot of those  
21       applications, the properties that got dumped into  
22       those models were questionable, to say the least.  
23       They have to put in a sound speed, a damping, a mass  
24       density, two phase flow sometimes. We've also looked  
25       at the acoustic models that were put together of the

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1       RPVs in particular and you get to regions where they  
2       wouldn't have a whole lot of elements, so you're  
3       trying to model a wave that looks like that and it  
4       might have two elements over that distribution,  
5       that's inappropriate. Also, the flow gets sucked  
6       into nozzles eventually and we looked at some of those  
7       models and they were sort of pretty coarse and  
8       discretized and instead of a pure circle, you've got  
9       sort of an octagon or something like that, and the  
10      area was wrong and things like that.

11               So, we put in the guidelines, hey, your  
12      properties have to make sense. So you can adjust  
13      them a little bit for benchmarking, but they can't  
14      deviate excessively from reality. Just try to get a  
15      better answer. Any acoustic model has to have at  
16      least six elements per acoustic wavelength, that's  
17      well established in my field, so that's now in the  
18      Reg Guide. And any time you have circular nozzle  
19      areas, you have to make sure the area is correct,  
20      either by adjusting it or whatever you want to do,  
21      you have to make sure that the area is represented  
22      properly.

23               MEMBER SKILLMAN: Is this is the physical  
24      area? Or the adjusted area based on some correlation  
25      factor?

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1 MR. HAMBRIC: No, no, it's the physical  
2 area. So, if you discretize something, you try to  
3 discretize a circle, you'll never get it right, it's  
4 always a little bit less than what it should be. So  
5 you just have to account for that and correct for it  
6 in their analysis so we have the correct area in  
7 there.

8 MEMBER SKILLMAN: Thank you.

9 MR. HAMBRIC: Next three blocks or slides  
10 are on forcing functions. And just to reiterate, we  
11 did the best we could to capture as many forcing  
12 functions as we could, but I think we tried to point  
13 out in the Reg Guide that any new design internal,  
14 external system, you have to consider what other  
15 forcing functions might be there and try to account  
16 for them. But hopefully we have enough examples in  
17 there to capture the flavor of what needs to be looked  
18 for so it's pretty rigorous. So, these are kind of  
19 broken into little pieces. So the dash is the  
20 lesson/observation, the arrow is the corrective  
21 action we took to modify the Reg Guide.

22 So the first is regarding pumps, there's  
23 more than one pump and in some cases, there are a  
24 whole bunch of pumps, and that can lead to pretty  
25 different flow distributions inside the Reactor

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1 Pressure Vessel. And, obviously, you can't, I don't  
2 think you can analyze every possible pump operating  
3 condition. So we say, the guidance is, use the flow  
4 distribution that gives you the highest possible  
5 local flow velocity, and that presumably gives you  
6 the worst case possible forcing functions.

7 MEMBER SKILLMAN: Steve, let me ask this  
8 question. We have a design that we're now reviewing  
9 that has four reactor coolant pumps, it does not have  
10 isolation valves. So, like these big four loop  
11 machines, you can have one pump running forward, two  
12 running forward, three running forward, four running  
13 forward. With one running forward, you've got  
14 backwards in three. If you've got two running  
15 forward, you've got a heck of a lot of flow running  
16 backwards in those other two loops. Is it the vision  
17 of this Reg Guide to address that?

18 MR. HAMBRIC: We tried, yes. We talk  
19 about multiple pumps and not only flow issues, but  
20 mechanical issues, what happens when you got all --

21 MEMBER SKILLMAN: I didn't see reverse  
22 flow, every once in a while when I raise that --

23 MR. HAMBRIC: Oh, we didn't talk about  
24 that.

25 MEMBER SKILLMAN: Okay. Bingo. I will be

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1 a witness of one that you get a big four loop plant  
2 and you run one reactor coolant pump at its highest  
3 density, at the coolant's highest density, you've got  
4 reactor coolant pump issues, motor current issues,  
5 and backward flow issues that really need to be  
6 addressed.

7 MR. HAMBRIC: So, in this Reg Guide, we  
8 could address that for what's happening inside the  
9 reactor, but --

10 MEMBER SKILLMAN: That's what I said.

11 MR. HAMBRIC: -- pumps are --

12 MEMBER SKILLMAN: This is -- it doesn't  
13 say -- the way you're addressing the replacement  
14 steam dryers, you are viewing them as they are  
15 affected by, clearly, the bells, lights, and whistles  
16 downstream. The location of your relief valves, the  
17 size of the stacks, the size of the standoffs, all of  
18 which are important. How about the Ps and their  
19 permutations and combinations?

20 MR. HAMBRIC: Right. This isn't  
21 necessarily aimed at steam dryers. This is  
22 recognizing that there are multiple pumps --

23 MEMBER SKILLMAN: Okay.

24 MR. HAMBRIC: -- and you're going to have  
25 multiple different potential flow conditions inside

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1 your reactor and then they take the most conservative  
2 one.

3 MEMBER SKILLMAN: I'm raising the issue of  
4 reverse flow.

5 MR. HAMBRIC: Right.

6 MEMBER SKILLMAN: I'm also raising the  
7 issue that I raised before, and that is,  
8 consideration for a broader description of what this  
9 Reg Guide is intended to address.

10 MR. HAMBRIC: Right.

11 MEMBER SKILLMAN: Okay.

12 MR. HAMBRIC: Good.

13 MEMBER SKILLMAN: Thank you.

14 MR. HAMBRIC: Yes, got that marked down.

15 MEMBER SKILLMAN: Reverse flow, I want  
16 that etched on your --

17 MR. HAMBRIC: We have that written down.

18 MEMBER SKILLMAN: -- pad here.

19 MR. HAMBRIC: That's a good point.

20 MEMBER SKILLMAN: Okay. Thank you.

21 MR. HAMBRIC: But the intent was, have the  
22 applicant come up with the most conservative  
23 combination of flows so that you had the highest  
24 possible local flow velocity.

25 MEMBER SKILLMAN: Well, I will tell you,

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1 if you got one on a big P with four loops, four  
2 reactor coolant pumps, you run the one --

3 MR. HAMBRIC: Right.

4 MEMBER SKILLMAN: -- you've got some flow  
5 issues that probably haven't been looked at real  
6 closely unless the designers have been thinking of  
7 the run-out and the effect of that run-out on what's  
8 flowing forward and what's flowing backwards.

9 MR. HAMBRIC: Right. So, for our efforts,  
10 can we get the name of the application you're looking  
11 at? Is that all right or not?

12 MEMBER SKILLMAN: Later.

13 MR. HAMBRIC: Later, okay. All right.  
14 So, the next one -- oh, lord. We've got to do two  
15 more bullets, sorry. So, not only do we need to look  
16 at the local flow velocities, but the response also  
17 depends on the phase distribution. So if you look at  
18 forcing functions coming from different locations,  
19 they're coming in at different times, so there's  
20 different phase distributions. The forces, in some  
21 cases, are turbulent, and that means they have random  
22 correlation over space. So the effect of correlation  
23 lengths matter.

24 And we're not asking an applicant to run  
25 all possible conditions, that's unreasonable. So

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1       instead, we're asking them to consider conservative  
2       simplifications, perhaps all in phase, all out of  
3       phase, perhaps maximum correlation lengths, just to  
4       make sure the forcing functions are bounding. That's  
5       really what we're after, is worst case response. And  
6       then the final bullet down below, there's been a lot  
7       of work over the years trying to assess the forcing  
8       function amplitudes of SRV resonances. We'll get to  
9       some of that in the scale model testing discussion  
10      coming up, but we've had applicants measure data and  
11      then try to extrapolate what they think the forcing  
12      function is going to be at a higher power, such as  
13      EPU, using inappropriately averaged data.

14               So, we've instead nailed them down and  
15      said, if you have a total excitation and you're  
16      measuring how that progresses over power flow, you've  
17      got to look at just that tone and how it changes over  
18      time instead of averaging over a really wide  
19      frequency band which can kind of mask that tone a  
20      little bit. So, Slide 2 out of 3 on our forcing  
21      functions. This get back to the importance of small  
22      geometry changes can have big impacts on forcing  
23      functions, unfortunately, in plants like these. And  
24      we just throw out a few examples.

25               For example, you have the flow coming

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1 over a standpipe opening, how sharp that corner is  
2 matters. Almost every plant now has sort of a  
3 smoothed corner to make sure that the strength of the  
4 resonance is mitigated. Just the physical  
5 dimensions, the length of an SRV, the diameter, all  
6 that matters, it changes the frequency where you get  
7 the peak. Clearances, structural supports, that can  
8 matter. The RPM of the reactor recirculation pump,  
9 if that aligns with the resonance or doesn't has a  
10 huge impact on the net response. So, we tried to  
11 give some guidance in the Reg Guide to address all  
12 that.

13 The first is looking at the different  
14 ways of assessing the forcing functions, either with  
15 CFD or scale model testing. And it may be obvious,  
16 but we've had applicants come with some pretty  
17 interesting proposals, but they've got to be accurate  
18 replicas, they've got to get the geometry right. Even  
19 if a smaller scale, it might be hard, but you have to  
20 get all those geometry details correct. If there are  
21 changes, this gets back to the limited prototype/non-  
22 prototype issue, the effects of the changes have to  
23 be addressed, both individually and cumulatively. So  
24 you can refer back to a previous successful design,  
25 but any deviation, you have to stack up those deltas

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1 and then tell us what they mean according to the  
2 forcing function.

3 A lot of times, we get one component that  
4 they consider a prototype that was big and then they  
5 wanted to scale it down into a smaller plant. That's  
6 okay to do, but you have to analyze the effects of  
7 those differences. And then finally, we've seen a  
8 lot of different reactor recirculation pumps in these  
9 different plants, they all have different drive  
10 frequencies, some are variable frequency drives, some  
11 are constant frequency drives. That has to be  
12 assessed, we have to look at what that means to the  
13 response of the internal. And numerical simulation.

14 So I think we're finally to the CFD and  
15 we can maybe answer that question you had earlier.  
16 Mostly where we see CFD being used is just to estimate  
17 flow velocities. And they'll take those velocities,  
18 hopefully worst case velocities, and go off to other  
19 empirical methods to estimate the forcing function  
20 amplitudes. We realize that computers are always  
21 getting better, tools are getting better, at some  
22 point, somebody is going to try to use CFD to assess  
23 the forcing function amplitude. So we realize that  
24 and we added some guidance to what to look for if  
25 that does happen.

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1                   But one of the big issues that comes in  
2                   with that is the bounding conditions. It's often  
3                   more straightforward to model an actual flow regime  
4                   or structure than it is to model its boundaries. For  
5                   a structure, for example, you say it's welded on to  
6                   another structure, well, where did you weld it and  
7                   how strong was the weld and what's the effect of  
8                   stiffness and is there a joint effect there? If  
9                   you've got a flow regime, you think you know what the  
10                  inflow is, you think you know what the discharge flow  
11                  is, but you have to model the pressure and the  
12                  velocity and the density, there are differences.

13                 There are always differences. Sometimes  
14                 they're variable, right? The plant operating  
15                 condition changes a little bit as you go from the  
16                 beginning of the fuel cycle to the end of the fuel  
17                 cycle. The flow speeds up so they can get more power  
18                 out of it. That changes things. So, the message is,  
19                 always conservative. What can you do to come up with  
20                 a bounding response? So, for the CFD, we need to  
21                 have the codes that are used validated, but they have  
22                 to be validated on plant components that are similar  
23                 to the components that are being designed. And that  
24                 means the proper geometrical complexity, proper flow  
25                 regime. So we need representative benchmarking

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1 before a simulation tool can be somewhat trusted.

2 And then, the boundary conditions have to  
3 be feasible and we have to look for conditions that  
4 give us a bounding response. This gets back to a  
5 little bit of the issue of CLDMs that might be inside  
6 containment. We've got these boundaries on the top  
7 and the bottom, it's moving up and down, what do you  
8 do? You can't model all of them, but try to look at  
9 the box that you're in and come up with the worst  
10 case boundary conditions for your assessment. So  
11 that's not necessarily a forcing function question,  
12 but it sort of got to be part of this and so, I  
13 figured I would point it out.

14 So, the question about when do we stop  
15 believing CFD and switch to SMT or other tests?  
16 That's a tough one. I think all we can do is review  
17 on a case-by-case basis -- I'm sorry, we're still  
18 back on the previous slide -- and look at the quality  
19 of the benchmarking, how good a job did they do with  
20 benchmarking a representative case? How rigorous  
21 were they with their conversion studies? How  
22 conservative are they? The latter is probably the  
23 most important, how conservative are they? Can they  
24 prove that they really chose conservative boundary  
25 conditions, conservative flow regimes, conservative

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1 Reynolds numbers, and that they're guaranteed to be  
2 applying a higher forcing function than what they're  
3 going to get in reality? If they can't prove that to  
4 us, then our belief drops and we start thinking, well,  
5 maybe we need some extra testing there to back you  
6 up, maybe supplement part of the CFD simulation.

7 MEMBER CORRADINI: Are the CFD -- this is  
8 a little bit off topic, so the Chairman will stop me.  
9 Are the CFD simulations all single phase?

10 MR. HAMBRIC: We didn't go that far.

11 MEMBER CORRADINI: But, my point is, when  
12 I do the CFD simulations, you've only -- when you  
13 look at them, those that are presented to you are  
14 mainly single phase simulations?

15 MR. HAMBRIC: So far, yes.

16 MEMBER CORRADINI: Okay.

17 MR. HAMBRIC: All right.

18 MEMBER CORRADINI: Okay, fine. Thank you.

19 MR. HAMBRIC: Okay. So, scale model  
20 testing. These are used more often than the CFD  
21 simulations. And we've broken this down into several  
22 little pieces. The first is dynamic similitude. We  
23 need to ensure that the SMTs have dynamic similitude.  
24 What does that mean? That means the mach number has  
25 to be right, so the flow rate divided by the speed of

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1 sound. In a reactor, we have steam, we have water,  
2 sometimes the scale model testing using air are  
3 different, so you have to properly account for the  
4 mach number there. And then something called a fluid-  
5 -elastic parameter, that's sort of the combination of  
6 the damping in the working fluid and the mass density  
7 in the working fluid.

8 So that has to be comparable,  
9 particularly in a scale model test, to what they're  
10 going to get in the real reactor. Or if not  
11 comparable, conservative. And that's what that  
12 second sub-bullet down there, only conservative  
13 distortions are acceptable. So you can use air, you  
14 can use other mach numbers, but you have to prove to  
15 us that you've done a conservative assessment, you're  
16 going to get a stronger forcing function than we would  
17 expect to see in reality. Second bullet is the  
18 effective Reynolds number. All scale model testing  
19 is invariably smaller, nobody ever builds a bigger  
20 scale model test. And those Reynolds numbers can be  
21 lower --

22 MEMBER BLEY: You're in an area I don't  
23 know real well with mechanical systems. When you do  
24 scaling, there must be things that affect resonant  
25 frequency and I'm not sure you can always define

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1       what's conservative if that sort of thing is  
2       happening. Can you talk at all about that?

3               MR. HAMBRIC: Right. That's sort of  
4       rolled into the mach number, the speed of sound you're  
5       assuming.

6               MEMBER BLEY: That kind of covers it?

7               MR. HAMBRIC: It partially does, but you  
8       have to look at your dimensions too.

9               MEMBER BLEY: Yes.

10              MR. HAMBRIC: So, you're trying to come up  
11       with a test that, at a given flow rate, has the right  
12       coupling to the acoustic response, which is similar  
13       to what you'd expect in a full scale plant.

14              MEMBER BLEY: But that's easy to say --

15              MR. HAMBRIC: It's easy to say --

16              MEMBER BLEY: -- but proving it is --

17              MR. HAMBRIC: -- and difficult to do.

18              MEMBER BLEY: Yes.

19              MR. HAMBRIC: That's right. That's  
20       absolutely right.

21              MEMBER BLEY: That's kind of tough.

22              MEMBER CORRADINI: But I guess, to  
23       Dennis's point, you're looking though to, I keep on  
24       coming back to what you said, you're looking to bound  
25       it. So if somebody is going to do a scale test, maybe

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1 two scale tests and then extrapolate from that, they  
2 might want to over, I don't want to say overdo, but  
3 go to an extreme relative to the fluid velocity so  
4 that I would excite the system more than I would  
5 expect it --

6 MR. HAMBRIC: Right. That's actually one  
7 of the ones, I think, in a future bullet.

8 MEMBER CORRADINI: Okay.

9 MEMBER BLEY: Okay.

10 MR. HAMBRIC: Yes. So there's a lot of  
11 steps you have to go through to prove that a scale  
12 model test and that your working fluid --

13 MEMBER BLEY: I guess, this is one place  
14 where like a page and a half in the Reg Guide seemed  
15 not to hint at the depth of what they have to do.

16 (Laughter.)

17 MR. HAMBRIC: Right. Yes. Samir is the  
18 expert on this, he's written long, long articles, we  
19 even cite a couple of them, I think, in the  
20 references, for further guidance, see these articles.

21 MEMBER BLEY: Well, we don't cite much in  
22 the way of references. I mean, there's only a handful  
23 of references in the whole thing.

24 MR. HAMBRIC: Right.

25 MEMBER BLEY: So there's -- mostly one

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1 would have to, well, one hopes you know what you're  
2 doing if you're going to use this anyway, but you'd  
3 have to have a pretty thorough background in --

4 MR. HAMBRIC: Correct.

5 MEMBER BLEY: -- the literature to be able  
6 to pull this off.

7 MR. HAMBRIC: Yes. This is not a  
8 textbook, it's a Reg Guide. So, again, the Reynolds  
9 numbers, we know they're smaller. And this gets to  
10 a little bit of one of the comments you guys made, a  
11 good way to demonstrate that the results are not  
12 influenced by further increase in Reynolds numbers is  
13 to run a little bit faster and then see. A typical  
14 way a Reynolds number affects work is, you get a  
15 forcing function, as Reynolds number goes up,  
16 eventually you sort of hit an knee in the curve and  
17 converge. So, I want to make sure that you've shown  
18 that you're kind of beyond that knee in the curve and  
19 you've converged. Next.

20 The scale model tests that we typically  
21 see are transient. So, what they've done is they'll  
22 take a pressure vessel, attach a bunch of pipes to  
23 it, put models of the standpipes and the pipe, and in  
24 the very ends of the pipes, they'll put a bunch of  
25 valves. And they'll pump holding up as high as the

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1 pressure rating will let it go and then get their  
2 instrumentation ready, turn on the acquisition  
3 system, and open up the valves and then do a blow-  
4 down. And the hope is they have enough capacity so  
5 that this blow-down is fairly steady state for a while  
6 and then starts dying off, the pressure starts  
7 rolling off to the point where the velocities go down  
8 and it's no longer relevant. So, that's the reality.

9 There's actually a transient test  
10 condition, the pressure is going down as we proceed,  
11 the temperature is going down, the velocity is  
12 slowing down. But, the issue is, these sorts of  
13 forcing functions depend significantly on those kinds  
14 of variations. The resonance peaks, I can do a little  
15 peak with my hand here, as you slow down, it's going  
16 to start getting wider and smaller. And you want to  
17 make sure that you're capturing the worst case  
18 forcing functions. So one of the things we added to  
19 the Reg Guide is, you've got to run multiple runs at  
20 the same test conditions so that we can establish the  
21 uncertainties, because it is a transient test, and  
22 the sampling over which they're doing the  
23 calculations, one second, two seconds, five seconds,  
24 ten seconds, we need to make sure that those give us  
25 bounding estimates of the forcing functions,

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1 realizing that you do have a transient test.

2 The parameter that typically comes out of  
3 these sorts of tests is called a bump-up factor. And  
4 this comes out of an EPU application. So they'll  
5 have operating plant data at a current power level,  
6 they want to go to some higher power level. They're  
7 not allowed to go to that higher power level to see  
8 how much stronger the forcing function is going to  
9 be, that's the whole point of the review process, to  
10 make sure it's okay to go to that power. So instead  
11 of doing it in the plant, they'll do it in a scale  
12 model test. They'll run a current power condition,  
13 go to what they tell us is a conservative EPU power  
14 condition, measure what happens to the forcing  
15 function, take the ratio and call it a bump-up factor.  
16 Somebody coined it that years ago and it sort of  
17 stuck, and sort we've sort of maintained it. So,  
18 it's the ratio of the loading at higher power level  
19 divided by the loading at a lower power level.

20 What they'll do is they'll take the  
21 forcing function in the actual plant at current  
22 power, multiply it by the bump-up factor, and say,  
23 here's what we expect it to be at EPU. And we hope  
24 that estimate is conservative. We have found that  
25 those bump-up factors depend on frequency, if you

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1 have a valve that's singing at 110 hertz, you've got  
2 a different bump-up factor than a different valve  
3 singing at 160 hertz. It's just different. Take  
4 that same valve and move it ten feet further down the  
5 main steam line, different. Put it close to another  
6 valve, different. Everything depends on the actual  
7 as-installed application.

8 And of course, uncertainties in the  
9 transient test. If you're not quite sure exactly  
10 what your flow rate is or exactly what your Reynolds  
11 number is or exactly what your mach number is, that  
12 gives you uncertainties. So, the bottom line is,  
13 it's okay for estimating, as long as we think you're  
14 conservative, but during power ascension, when you  
15 get to the end, you've got to validate that your bump-  
16 up factor was right. And you essentially replace  
17 that bump--up factor with what happened in actual  
18 plant. Another thing we can do is, if we're uncertain  
19 about mach numbers and Reynolds numbers, is just  
20 extend the SMT to even farther beyond where you think  
21 the actual power plant condition is, so we have some  
22 margin, we're getting a true worst case.

23 And we have had applicants come back to  
24 us and say, well, away from this resonance, we did  
25 the ratio of EPU versus CLTP and we actually got lower

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1 forcing functions. That's a measurement error. So  
2 we established a long time ago that the absolute  
3 minimum bump-up factor that you can physically have  
4 is the square of the flow velocity ratio, that's just  
5 flow physics. So that's a bare minimum. Okay.

6 We talk about structural response,  
7 structural modeling, flow induced forcing functions,  
8 CFD to predict the forcing functions, scale model  
9 tests, you piece all that together and you come up  
10 with a final assessment of what we think the structure  
11 vibration is, the structure strain is, the structure  
12 stress is, and compare that against an allowable  
13 limit. We need benchmarking of that whole process.  
14 And we first started on this procedure back in the  
15 Quad Cities days.

16 What the applicants were doing is they  
17 would benchmark the forcing function part, they would  
18 benchmark the structural response part, they would  
19 benchmark the mapping of loads to a structural model.  
20 They'd benchmark all those pieces and then they would  
21 say, all of these components in the analysis  
22 procedure are unrelated to each other, they're not  
23 correlated, that means we can combine all the bias  
24 errors and uncertainties, using square root sum of  
25 the squares. And we accepted that for a while until

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1 we got to Susquehanna, and the end-to-end  
2 measurements of strains on an actual operating dryer  
3 were much higher than the predictions. Much higher  
4 than the predictions plus the SRSS bias correction.  
5 What's going on? Clearly some forcing functions were  
6 not accounted for or some structural response  
7 components were not properly accounted for.

8 And the lesson learned there was end-to-  
9 end benchmarking is the best way to go. Put either  
10 accelerometers or strain gauges, some sort of a final  
11 measurement on the reactor internal. By definition,  
12 it has to include everything, the actual structure is  
13 loaded by whatever it's loaded by, it's responding  
14 however it wants to respond. And in spite of  
15 everything you've done, if you don't properly capture  
16 that, you apply a bias correction to it based on the  
17 final measurement and you apply an uncertainty based  
18 on the statistical assessment of several  
19 measurements, and that does it, that captures any  
20 neglected issues in your procedure. So we think  
21 that's quite powerful and we highly recommend that  
22 approach be used. Okay

23 MEMBER SKILLMAN: But, Steve, what you are  
24 saying is, every design needs to be fully  
25 instrumented.

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1 MR. HAMBRIC: No. No, we cover that  
2 earlier in the Reg Guide. It's only components that  
3 we are concerned about, that we think may have a flow-  
4 induced, acoustically-induced, mechanically-induced  
5 strong vibration. You don't want a margin --

6 MEMBER SKILLMAN: So we're back to the  
7 steam dryer at Susquehanna with some unresolved  
8 questions and your guidance is --

9 MR. HAMBRIC: We force them to apply a  
10 bias to it. And steam dryers have failed, that's why  
11 we're spending all that attention on it. But if  
12 you've got a component that's never failed and you  
13 can prove to us with a lot of margin for safety that  
14 there's no significant forcing functions to worry  
15 about, there's no reason to have to go off and  
16 instrument it.

17 MEMBER RICCARDELLA: But how would you do  
18 end-to-end on a non-prototype or limited prototype if  
19 you're not putting gauges on the one end?

20 MR. HAMBRIC: Again, only if we think we  
21 have reason to believe there's a strong forcing  
22 function response that gets you close to the  
23 acceptance limits.

24 MEMBER CORRADINI: But, maybe I  
25 misunderstood, end-to-end in your definition is not

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1 simply instrumenting the steam lines.

2 MR. HAMBRIC: No, that's --

3 MEMBER CORRADINI: That would be under the  
4 category of limited or non-prototype?

5 MR. HAMBRIC: Remote monitoring is what  
6 that is. But for a structure that's had all the  
7 problems the steam dryers have, we've said, hey, if  
8 you want to change the design or change the operating  
9 conditions or do something different, you need to go  
10 in there and prove to us things are okay so we don't  
11 have a Quad Cities on our hands again.

12 MEMBER RICCARDELLA: But then is that  
13 voiding out this concept of limited prototypes and  
14 non-prototypes for steam dryers?

15 MR. HAMBRIC: I don't think so.

16 MR. WONG: In the guidance, for limited  
17 prototype, we -- excuse me, for non-prototype,  
18 there's a statement saying for EWL steam dryer, the  
19 applicant need to provide significant justification  
20 in order to classify the steam dryer as a non-  
21 prototype. And in our EPU experience, all units need  
22 to monitor the main steam line at a minimum.

23 MEMBER RICCARDELLA: But that won't give  
24 you end-to-end?

25 MEMBER SKILLMAN: No. That's --

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1 MR. HAMBRIC: No, but they've benchmarked  
2 their procedures on another dryer and proven that  
3 they're conservative, with bias correction.

4 MEMBER REMPE: Can we talk about another  
5 example, it's in your backup, Browns Ferry, that's  
6 coming to us?

7 MR. HAMBRIC: Okay.

8 MEMBER REMPE: Apparently, it tried to do  
9 an EPU with the existing dryers and it failed, and I  
10 don't know the details and I'm curious, and now they  
11 are going to have replacement steam dryers. Are they  
12 going to do what Peach Bottom did, one heavily  
13 instrumented, others not? Or what's the -- could you  
14 give us the real world story on that one?

15 MR. HAMBRIC: Yes. That's the plan. I'm  
16 sure we'll be in front of you again --

17 MEMBER REMPE: I'm sure you will too --

18 MR. HAMBRIC: -- in a year, but --

19 MEMBER REMPE: -- but I'm just curious  
20 about what happened as it relates to this Reg Guide  
21 and how the Reg Guide adequately covers that  
22 situation.

23 MR. HAMBRIC: They don't have to follow  
24 this Reg Guide, is my understanding, because it  
25 hasn't been issued yet.

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1 MEMBER REMPE: Right, but --

2 MR. HAMBRIC: But they are making the  
3 attempt.

4 MEMBER REMPE: -- there will be another  
5 plant in the future, and it may not be a steam dryer,  
6 and I'm just wondering, can you talk a little bit  
7 what happened when they failed?

8 MR. HAMBRIC: Old application? Yes. The  
9 old application essentially comes down to poor  
10 quality plant measurements. There's a lot of noise  
11 in the measurements you saw earlier, electromagnetic  
12 noise, that they just could not remove in a fashion  
13 to convince us they weren't being non-conservative  
14 about it.

15 MEMBER REMPE: Okay.

16 MR. HAMBRIC: So they just did not have  
17 good quality plant data and could not prove to us  
18 that the existing dryers were going to meet the  
19 acceptance levels. Going forward, yes, the first  
20 dryer, I think I can say this, if anybody wants to  
21 stop me, you can, but they're going to instrument the  
22 first one and after that, it's going to be main steam  
23 line monitoring.

24 MEMBER REMPE: Okay.

25 MR. HAMBRIC: And if we have an issue like

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1 we had on Peach Bottom, we'll --

2 MEMBER REMPE: We'll be back.

3 MR. HAMBRIC: -- adapt and overcome.

4 (Laughter.)

5 MEMBER REMPE: Okay. Just curious. Thank  
6 you.

7 MEMBER RICCARDELLA: Since Quad Cities,  
8 that event, has anybody been able to implement an EPU  
9 without replacing their steam dryer?

10 MR. HAMBRIC: Yes. Hope Creek, and  
11 Vermont Yankee made modifications to their dryer, did  
12 not replace it, beefed up the outer banks of it. Nine  
13 Mile, but they beefed up their structure a little  
14 bit. So there have been modifications made to try to  
15 improve the strength. So, yes, there's been at least  
16 those three, VY, Hope Creek, and Nine Mile. I think  
17 on the backup, there should be a list of all the  
18 dryers. And I thought we put in there one of the  
19 columns that said replaced or retained. If not, we  
20 certainly have it.

21 MEMBER REMPE: It's not really a call-in,  
22 but there's a discussion about it in there.

23 MR. HAMBRIC: Right. And the next block,  
24 Yuken was going to cover, right?

25 MR. WONG: Yes. The next Lessons Learned

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1 is the structural stress calculation. The structural  
2 analysis of reactor internal core support structures  
3 follow the guidance in ASME Boiling and Pressure  
4 Vessel Code Section III Subsection NG. The non-  
5 safety related reactor internal components, such as  
6 the steam dryer, also adopt the ASME Code Subsection  
7 NG to ensure structural integrity. The limits on the  
8 various stressors, including fatigue stress due to  
9 cyclical loading, need to be satisfied. This is to  
10 ensure high frequency excitation mechanisms will not  
11 cause high cycle fatigue.

12 To perform the stress analysis, it is  
13 necessary to have conservative estimates of local  
14 stress concentrations, such as at fillet welds. To  
15 address these issues, detailed guidance for  
16 structural analysis were included in the Reg Guide.  
17 The guidance include how to perform successive mesh  
18 refinement to achieve stress convergence. Next one,  
19 please.

20 MEMBER SKILLMAN: Why should an applicant  
21 or the ACRS be comfortable with this? The guidance  
22 for internals design has been available for years and  
23 highly qualified well intentioned men and women  
24 designed internals in accordance with Section III NG  
25 and we have internals that cracked. And so, we're

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1 saying, oh, by the way, we're going to do a couple of  
2 other things. Why should we be confident that a  
3 couple of other things are going to solve the problem?  
4 Where's our comfort going to come from? Is there  
5 something else going on that we aren't considering?

6 MR. SCARBROUGH: In the past, the steam  
7 dryer was not typically Subsection NG. If you --  
8 there's been, like, stories of how these were just  
9 sort of made in the garage, right? They were -- the  
10 original steam dryers did not have the pedigree that  
11 they do now. But with the improvements, the  
12 applicants and licensees are saying, well, we're just  
13 going to design it to NG, except they take some  
14 liberties with regard to some non-structural parts,  
15 like the fillet welds, and they don't sort of follow  
16 all the quality requirements, all of those additional  
17 requirements that are in NG because they feel that  
18 they're non-load bearing welds and joints and they  
19 can use something a little less. It's that little  
20 less that gets us involved in terms of what they're  
21 going to do.

22 And there was a lot of discussion with  
23 the ESBWER, with GEH, in terms of how they were  
24 analyzing these fillet welds. And a lot of this  
25 discussion had to do with, like Yuken mentioned, was

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1 the convergence of the solutions in terms of what  
2 they were assuming. So, what the Reg Guide does, it  
3 lays out a couple of different approaches that were  
4 worked out between the NRC Staff and the analysts at  
5 GEH in terms of what would be a reasonable way to  
6 evaluate the sort of non-structure bearing joints,  
7 these fillet welds, in a steam dryer, so that they  
8 would maintain their structural integrity and not  
9 generate any loose parts. So, that's what we're doing  
10 in this section. We're trying to provide additional  
11 guidance to help the licensees so when they come in,  
12 they'll know what's a reasonable to way to try to  
13 deal with these portions of the dryer from a  
14 structural point of view.

15 MR. WONG: I would like to also add, the  
16 steam dryer failure example, they did not properly  
17 account for all the excitation mechanisms, such as  
18 the acoustic resonance. So in this Reg Guide, we try  
19 to explain all the different excitation mechanisms,  
20 make sure the applicant will consider each one.

21 MEMBER RICCARDELLA: I think it's fair to  
22 say that things didn't fail because the NG stress  
23 limits were inadequate, they failed because they  
24 didn't define the loads properly.

25 MR. SCARBROUGH: That's correct.

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1 MEMBER RICCARDELLA: And if you defined  
2 the loads properly, they were higher than the NG  
3 stress limits.

4 MR. SCARBROUGH: We've also had issues  
5 with, I think, weld quality on Susquehanna, right?  
6 Which I think we've since addressed. And Quad Cities  
7 weld quality issues, the residual stress problems on  
8 some of the other dryers, they've since corrected  
9 their design to make sure that doesn't happen again.

10 MEMBER RICCARDELLA: I suspect those were  
11 built before NG was published, right?

12 MR. SCARBROUGH: Susquehanna was new,  
13 right? Yes.

14 MEMBER RICCARDELLA: Oh, that was a new  
15 steam dryer?

16 MR. SCARBROUGH: Yes.

17 MEMBER RICCARDELLA: Okay.

18 MR. SCARBROUGH: They just weren't  
19 following NG because they didn't feel that it was  
20 really needed. And it wasn't until -- licensees have  
21 done a tremendous job in terms of improving the  
22 pedigree and the quality of building the steam  
23 dryers. I give them credit for that. They really -  
24 - and they use NG for most of the situations, but  
25 there are some places where they feel that they can

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1 do something less and we work with them and come up  
2 with some reasonable guidance of what's acceptable.

3 MEMBER RICCARDELLA: Okay.

4 MR. WONG: Okay. Next slide.

5 MEMBER RICCARDELLA: Thank you. Okay.

6 MR. WONG: In the structural analysis, to  
7 capture the rapid time variation and spatial  
8 variation of the dynamic input, the input time step  
9 need to be short enough and the model mesh need to be  
10 fine enough. The structural model mesh and the  
11 surface loading mesh usually are different. To  
12 address the time input issue, for the time analysis,  
13 the time step should be no larger than one quarter of  
14 the shortest period of interest. As an example, for  
15 the frequency interest of 250 hertz, the solution  
16 time step should no larger than 0.0005 second. The  
17 input time increment may no larger than a quarter of  
18 the shortest period of interest. To address the mesh  
19 differences of the structural and the loading model,  
20 the generated load distribution and the applied load  
21 distribution should be checked. And this is  
22 particular in areas of high stress to ensure  
23 conservative load mapping has occurred. Next one.

24 MEMBER RICCARDELLA: Just to correct the  
25 record, I think for that first arrow, you said one

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1 quarter, I think you meant one eighth, right?

2 MR. WONG: One eighth, yes. Thank you for  
3 correction. Fillet welds are used to connect thin  
4 plates to heavy sections, such as a typical steam  
5 dryer. The fatigue evaluation procedures and  
6 acceptance criteria of the fillet welds typically  
7 follow ASME Subsection NG. The stress concentration  
8 factors, or known as fatigue strength reduction  
9 factors, are needed to ensure reasonable estimates of  
10 total stress for fatigue evaluation of fillet welds.  
11 The total stress includes the peak stress due to local  
12 discontinuities, such as a weld.

13 The Reg Guide describe two acceptable  
14 methods to calculate for the weld stresses. The first  
15 method, the fillet weld is included in the finite  
16 element global model without the fillet details. The  
17 nominal stress at the weld juncture is multiplied by  
18 a factor of four as specified in Subsection NG. And  
19 in the second method, the geometry of the fillet weld  
20 is modeled in the solid element model. The linearized  
21 stress on the throat of the fillet weld is multiplied  
22 by a factor of three. And the Staff found both  
23 methods provide a consistent level of conservatism.

24 MEMBER RICCARDELLA: Shouldn't there be a  
25 third method where you would allow an applicant to do

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1 some testing to develop his own fatigue strength  
2 reduction factor? Going from one to two seems like  
3 an awful lot of additional effort just to get from  
4 four to three, and these fatigue strength reduction  
5 factors are basically empirical developed by fatigue  
6 testing.

7 MR. SCARBROUGH: We could add something  
8 there where an applicant could propose a separate  
9 program. I mean, this was just examples.

10 MEMBER RICCARDELLA: Okay, well --

11 MR. SCARBROUGH: Yes, we could do that.  
12 We could add that.

13 MEMBER RICCARDELLA: Well, they're kind of  
14 not written as examples, they're --

15 MR. SCARBROUGH: As the two methods, yes.

16 MEMBER RICCARDELLA: -- written as two  
17 acceptable methods.

18 MR. SCARBROUGH: Yes, we'll look at the  
19 wording and the applicant always --

20 MR. MORANTE: Tom, can I say something on  
21 that?

22 MR. SCARBROUGH: Yes, please do, Rich.

23 MR. MORANTE: I think it would be pretty  
24 difficult for an applicant to do a sufficient amount  
25 of testing to demonstrate that the peak strength

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1 reduction factor is appropriate. Now, it can be added  
2 here, but I don't think, number one, that many  
3 applicants would take that route and, number two, it  
4 may be difficult for them to do a sufficient amount  
5 of testing to adequately demonstrate a different  
6 fatigue strength reduction factor than what the code  
7 currently specifies.

8 MEMBER RICCARDELLA: The factor of three  
9 and the second step, that's a code value or is that  
10 one that you --

11 MR. MORANTE: No.

12 MEMBER RICCARDELLA: -- came up with?

13 MR. MORANTE: No, that is not a code  
14 value, but what we looked at was, if you made a local  
15 model which included a nominal representation of the  
16 fillet, that if you multiplied the stress at the root  
17 on the throat --

18 MEMBER RICCARDELLA: Yes.

19 MR. MORANTE: -- the linearized stress at  
20 the root on the throat and you multiplied it by three,  
21 you would get comparable conservatism to the first  
22 approach, which is just more like the traditional way  
23 where you calculate a moment and a force at the  
24 juncture and you apply your factor of four, which is  
25 in the code. So, we accepted the second method only

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1 on the basis of a comparison through a parametric  
2 study that conservative predictions would be arrived  
3 at, that were comparable to using the first method.  
4 But, no, the second method is not in the code.

5 MEMBER SKILLMAN: Let me ask this,  
6 theoretical question, but it's one that I've dealt  
7 with in the past, where the effort has been focused  
8 so greatly on making the structure strong in terms of  
9 the size of the weld, the gussets, the internals,  
10 that are just much like a Sherman tank, that under  
11 changing thermal conditions or changing flow  
12 conditions, the strong device has almost become  
13 brittle to where it's not able to respond and the  
14 only way it does is by failing a section of the metal.  
15 In other words, it's so strong it is no longer  
16 sufficiently flexible for the environment in which it  
17 dwells. Can we be in the situation here where we  
18 have virtually over designed, to our detriment?

19 MR. WONG: One thing I would comment, the  
20 steam dryer, I think, sits on top of the reactor  
21 internal components, so usually it's free to expand.  
22 So thermal stress may not be a critical issue.

23 MEMBER SKILLMAN: Well, normally thermal  
24 stresses are self-relieving, unless the rate of  
25 change is so great that it can't relieve itself the

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1 way it wants to and so, what it does is it fails. It  
2 just goes, clink, and you end up with a split weld.

3 MR. SCARBROUGH: Right. And I think it's  
4 important for the licensees or applicants to look at  
5 their steam lines and what would be their driving  
6 functions. I agree with you that just making a  
7 bigger, bigger brick may not be the right answer. If  
8 you look at what your forcing functions are, you  
9 design your dryer so that it's fully sufficient for  
10 that, but you don't need to make a brick if they can  
11 show that their forcing functions are something  
12 that's reasonable for that dryer.

13 MR. MORANTE: Let's start off on the  
14 premise that they're using ASME code materials. Now,  
15 typically ASME code materials are selected because  
16 they exhibit a significant amount of ductility.  
17 These are not materials that are ultra high strength.  
18 And typically, they would exhibit a significant  
19 ductility or the code wouldn't have them in there,  
20 unless for certain applications. One of the problems  
21 here with the fatigue is that these are high cycle  
22 fatigue issues, which means the allowable maximum  
23 stress is quite low compared to a yield strength. I  
24 don't know much about the issue of rapidly changing  
25 thermals on producing brittle behavior. If that's a

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1 real issue, then it ought to be addressed.

2 MEMBER SKILLMAN: Thank you.

3 MEMBER RICCARDELLA: The only thing that  
4 might lead to brittle behavior is if you have some  
5 components that are in a very highly irradiated zone.  
6 I mean, it's stainless steel, it's pretty ductile  
7 stuff, but --

8 MR. MORANTE: It's very ductile.

9 MEMBER RICCARDELLA: -- if you had, like  
10 we're dealing with baffle bolts, for example, and  
11 very highly irradiated, there is some embrittlement  
12 going on there.

13 MR. SCARBROUGH: Oh, okay. Great, thank  
14 you.

15 MR. HAMBRIC: So, the next couple of  
16 blocks of slides are on measurements. The first  
17 couple are on instrumentation and then the next few  
18 are just on measurement procedures in general. For  
19 instrumentation, the first section is actually on  
20 where you measure. And you can't just slap sensors  
21 anywhere, whatever internal you're looking at,  
22 whether it's a dryer or something else, the  
23 measurement locations have to correlate to high  
24 vibration and hopefully fairly close to high stress  
25 regions, so that they're actually relevant to a

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1 structure's condition during power ascension.

2 So we added to the Reg Guide was that  
3 accelerometers had to be near peak or near-peak  
4 response locations. You get those out of the  
5 simulations, so they'll simulate the response and  
6 then use those to guide the accelerometer locations.  
7 Strain gauge is a little bit different, you want to  
8 put those in locations where you have minimum  
9 gradients in strain. The reason for that is you want  
10 to minimize your measurement uncertainty. So if you  
11 put yourself in a location where there's a really  
12 strong gradient, that means you've got a plus or minus  
13 of quite a bit on your measurement and that becomes  
14 problematic when you want to do your benchmarking  
15 against the simulation.

16 And typically we ask the applicants to  
17 show that the sensor locations, the response to the  
18 sensor locations is highly coherent with the critical  
19 response locations. So, an issue we have is you can't  
20 put strain gauges on locations of high stress, those  
21 are usually right at welds or other joints. And so,  
22 the gauges have to go kind of close to them, but not  
23 exactly. So, where is that kind of close? And to  
24 prove they're close enough, they'll do a coherence  
25 assessment between the peak stress location and where

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1       they put the sensor and show that there's a good  
2       strong coherence there, so that it's relevant to the  
3       high stress location.

4               MEMBER SKILLMAN: Let's go back. Perhaps  
5       this is where you can answer my question relative to  
6       the sensor being affected versus the sensor  
7       displaying or revealing what the structure that it is  
8       attached to is displaying.

9               MR. HAMBRIC: So are you concerned about  
10       the accuracy of the gauge itself or are you concerned  
11       that the installation of the gauge is affecting the  
12       stiffness of the structure?

13              MEMBER SKILLMAN: Not so much about the  
14       accuracy of the gauge itself, more concerned about  
15       being deceived because the gauge is responding to the  
16       stimulus, but not displaying the reaction of the  
17       structure to which it is attached.

18              MR. HAMBRIC: Yes, I think that's the next  
19       three slides that we talk a bit --

20              MEMBER SKILLMAN: Okay.

21              MR. HAMBRIC: -- about that and we can  
22       continue the discussion. Sorry to put you off yet  
23       again, but --

24              MEMBER SKILLMAN: That's okay. Thank you.

25              MR. HAMBRIC: So, this next one is

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1 specific to main steam lines. The standard operating  
2 procedure has become the use of circumferentially  
3 oriented strain measurements, which when summed are  
4 directly proportional to the internal pressure. The  
5 observations we have made is it sounds easy, but for  
6 whatever reason, we've had a lot of problems from  
7 several applicants. Repeatability issues, they'll  
8 measure it one year and they'll measure it the next,  
9 big differences. Sensors have failed. Background  
10 noise is way too high, that was the issue we had in  
11 the initial Browns Ferry application. Or just QA  
12 problems, operator error, have led to some pretty, in  
13 some cases small errors, in some cases really  
14 egregious errors.

15 So the guidance we've given is that you  
16 have to have at least four working gauges around the  
17 circumference. Most applicants go with double that  
18 just to give them some margin in case some of the  
19 sensors fail, and they do. We're also recommending  
20 a standard operating procedure that a static  
21 pressurization calibration be done, where you know  
22 what the internal plant pressure is, you measure your  
23 hoop pressure, make sure that you're getting the same  
24 thing. And we've had problems with that too. There  
25 have been calibration errors that we've had to live

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1 with because they did not go through that test, so  
2 we're recommending that in the future.

3 And there's always a pretty good gap, a  
4 couple years at least, between the submission of an  
5 application, for an existing plant anyway, and when  
6 power ascension starts. And so, we're requiring that  
7 updated measurements be made right before they start  
8 power ascension, just to make sure that they're still  
9 relevant and reasonably close to what they got during  
10 the application process. All right.

11 So in-plant measurements. These overlap  
12 a little bit, but again, we've had some measurements  
13 that have been absolutely unacceptable, the channels  
14 were wrong, they took one channel, plugged it into  
15 one number, another channel plugged in another  
16 number, didn't update what happened in the data  
17 acquisition system. Humorously incorrect  
18 calibrations were applied, orders of magnitude  
19 differences and they've tried to convince the results  
20 were okay. And we set them straight on that. High  
21 EMI interference, we've had people that run  
22 instrumentation wires next to power lines, not a good  
23 thing to do.

24 So, to correct for that hopefully in the  
25 future, we added some general in-plant measurement

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1 guidance. Number one, all instrumentation has to  
2 properly function in the plant, high temperatures,  
3 high pressures, high moisture content. And here, I  
4 think, is maybe your question, the as-welded strain  
5 gauge calibrations are required. So, when you buy  
6 these strain gauges, they'll tell you how to weld  
7 them, but sometimes they'll weld them a little bit  
8 differently in a plant and the base structure is a  
9 little bit different from what the calibration spec  
10 says.

11 So it's that kind of thing that we've  
12 asked the applicants to get a little more rigorous  
13 about, that they come up with a calibration that is  
14 based on a representative application or  
15 installation. Take a plate that has about the same  
16 thickness, use the same welds, go through the  
17 calibration process and use corrective calibrations  
18 for in-plant applications. The other thing you can  
19 do with strain gauges is they're almost self-  
20 calibrating. If you calibrate them once, you can  
21 calibrate them again by just applying a voltage to  
22 it. It's called shunt calibration. So, we recommend  
23 that and a lot of people have been doing that, which  
24 is good. So I don't know if that addresses your  
25 question or not. They prove to us that the

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1 calibration is correct on a representative  
2 installation.

3 MEMBER SKILLMAN: It goes part of the way  
4 towards my question. And I guess as I think of how  
5 these tests are done in the field, there is some  
6 discipline to ensure that the location of the stress  
7 gauge, strain gauge is, if you will, protected and  
8 that it is in fact giving an indication  
9 representative of the base to which it is attached,  
10 as opposed to being wedded or blanketed by or somehow  
11 affected by an external environment that would cause  
12 that gauge to not reflect the underlying surface that  
13 it is intended to monitor.

14 MR. HAMBRIC: Well, they're all qualified  
15 for in-plant pressure, temperature, moisture  
16 conditions. So that should be taken care of. And  
17 then, to make sure the cal is correct, we just make  
18 sure they've applied it to a representative  
19 structure. I think that's about as much as we can  
20 do.

21 MEMBER SKILLMAN: It sounds like you had  
22 a bad experience --

23 MR. HAMBRIC: A couple of years worth.

24 MEMBER SKILLMAN: -- trying to get to  
25 here. It took a couple of years to finally figure

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1 out how do to exactly what Steve's talking about.

2 MR. HAMBRIC: So they've mounted these  
3 strain gauges, at least one applicant has, to flat  
4 plates, done them again to curved pipes, and then the  
5 final, at least for main steam line measurements, the  
6 proof in the pudding was a calibration against the  
7 known internal pressure. Now, you can't do that with  
8 every internal structure, but at least we could do it  
9 there, so that gave us some confidence.

10 MEMBER CORRADINI: And that is one of the,  
11 if I remember correctly, a couple slides back, that's  
12 what's now you're recommending.

13 MR. HAMBRIC: Yes, we put that in the Reg  
14 Guide that it's highly recommended. I don't know if  
15 we're allowed to use the word highly, but we  
16 recommended it. And then, finally, the last couple  
17 are, don't run instrumentation and don't put the  
18 instrumentations near high EMI regions. You're  
19 measuring voltage, so don't corrupt the voltage. And  
20 even data acquisition systems have their own  
21 calibrations that need to be done periodically. They  
22 have noise floors that need to be addressed. Okay.

23 MEMBER SKILLMAN: Okay. Thank you.

24 MR. HAMBRIC: And I think this is my last  
25 slide. We've had -- because it's a nuclear power

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1 plant, because there's a lot of EMI, there are real  
2 life issues that can corrupt data. We've had to  
3 address dealing with various proposed noise reduction  
4 methods that applicants have thrown at us. The  
5 obvious ones to get rid of are electrical tones,  
6 you've got 60 hertz multiples, that's fine, they need  
7 to go away. RRP drive frequencies, not vane passing  
8 frequencies, but the drive frequencies, those are  
9 electrical, so those are non-relevant, they don't  
10 drive structures or anything like that, and they can  
11 be removed.

12 And then, all measurement systems,  
13 whether it's from the sensors, the cabling, the data  
14 acquisition computer itself, have a broadband noise  
15 floor. That's just life. So, what we put in the  
16 guidance is that you can use noise reduction methods,  
17 provided they do not remove excessive signal. We've  
18 had some pretty egregious attempts to remove signal  
19 back in the old days, which are not allowed, but we've  
20 come through. So we don't allow excessive signal  
21 reduction.

22 To get rid of electrical tones, something  
23 called notch filtering is typically used. You can  
24 set this up in a signal processing software pretty  
25 easily. But what you get in your signal is you get

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1       this huge dip where there's almost no signal at 60  
2       hertz, there's no signal at 120 hertz, and so we've  
3       recommended that sort of some random noise be put  
4       back in to backfill so you don't get a big dip in  
5       your signal, because we know there's at least some  
6       excitation there.

7               We've had different approaches for  
8       broadband noise reduction suggested. One is  
9       something called coherence processing, where you'll  
10      use a nearby sensor that you think is associated with  
11      your background noise and remove all signals  
12      associated with that from the signals that you care  
13      about. So without getting into huge detail, we've  
14      said that's okay as long as you substantiate it,  
15      usually with an example problem or a demonstration  
16      and, once again, prove to us you've not removed  
17      excessive signal.

18             A more clever way of doing it lately has  
19      been suggested, it's called wavelet noise reduction.  
20      This is used quite a bit in image processing, so if  
21      you've got Photoshop, chances are you've got a  
22      wavelet based noise reduction there to get rid of  
23      little pops in your images. You can do the same thing  
24      in a one--dimensional time series. But, again, we  
25      require that it be demonstrated and proven to be not

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1 excessive noise reduction and substantiated with an  
2 example problem. And a big one is a while ago we had  
3 somebody try to use one noise reduction method to  
4 qualify a design and a different noise reduction  
5 method during power ascension. That was  
6 unacceptable, consistency is required. So we put  
7 that in the Reg Guide as well. And I think you're  
8 taking over.

9 MR. SCARBROUGH: Okay. I'll take over.

10 MR. HAMBRIC: So I'm going to hang around  
11 for another 15 minutes and then probably duck out.

12 MR. SCARBROUGH: Okay.

13 MR. HAMBRIC: Now, what I may do is call  
14 into the number while I'm driving out to the airport,  
15 so if you have a question during --

16 MR. SCARBROUGH: Great, thank you. The  
17 next set of slides, what I wanted to do was just let  
18 you know that we've taken the Lessons Learned from  
19 all the power ascension and license conditions that  
20 we've developed over the years for all the EPUs, where  
21 we have a slow and deliberate power ascension process  
22 that we have where we review the plan and there's a  
23 75 percent power sort of baseline and there's five  
24 percent increments as they go up and then they hold  
25 for 72 hours at 75, 85, and 95 percent and send us

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1 the information and make sure our consultants get a  
2 chance to take a look at it. Then when they get up  
3 to 100 percent, they give us the data within 72 hours  
4 and then 90 days later, they give us the full analysis  
5 and then they do two refueling outages inspections in  
6 a row and then they develop a long-term plan based on  
7 what they see.

8 So, we've sort of taken that sort of  
9 generic Lesson Learned and applied it into the  
10 guidance in the Reg Guide. So here these slides  
11 basically are saying that the sensors and wiring and  
12 data acquisition systems may change slightly over  
13 time due to aging. And so, all this has to be done.  
14 Grand Gulf, they had their sensor on, then they were  
15 running for a while and they started losing some  
16 sensors, and so, that's all something to be concerned  
17 about. And how you develop your limits, your power  
18 ascension limits, there's root mean square, there's  
19 frequency dependent limits, which is what we  
20 typically, I call, limit curves, where they look at  
21 the differences between and they anticipate making  
22 sure that by the time they get to the next level,  
23 they haven't exceeded one of those limits.

24 In terms of the peak and RMS, you have to  
25 make sure you have the proper number of sensors and

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1       that you don't have -- all your important resonances  
2       and forcing function frequencies are bounded. But if  
3       you get to what we call limit violations, when we  
4       talk about limit curves, there's Level 1, Level 2,  
5       you have a hold at one point, you reduce power at  
6       another, you analyze and determine if you have  
7       anything that's happening there that's significant.  
8       A lot of times, what you'll see is you'll see a sharp  
9       resonance pop up and they'll jump up and hit a limit  
10      curve or get close to a limit curve and then they  
11      have to analyze, okay, why is that?

12             And they do things that Steve was just  
13      talking about in terms of, okay, it's not  
14      significant, it's just a peak and it's not going to  
15      cause a problem in terms of the overall structural  
16      integrity of the dryer. So they give you that. They  
17      analyze, they make sure that, like we say, these  
18      sensors have finite lives, so you want to move things  
19      along. They reanalyze, reanalysis you perform using  
20      the methods to anticipate where you're going. And  
21      then you do a final structural analysis using your  
22      full procedures. Next, we have -- the next slide.

23             In terms of the limits themselves, you  
24      update them at every power ascension, because things  
25      change and you have small peaks come and go as you go

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1 up in power. Your responses are projected up to a  
2 full power level, you don't want to end up hitting a  
3 limit if you know you're going to get there before  
4 the next power level, so you look at that. And then  
5 you look at coupled resonances where you might end up  
6 having a combination of the flow-induced vibration or  
7 acoustics or something adding up so you might end up  
8 hitting a peak.

9 But the bottom line during all that is  
10 the Staff monitors that power ascension, basically on  
11 a 24 hour basis. I think all of us have been on 24  
12 hour call when they're going up, over the EPU, that  
13 week time period when they're going up and they're  
14 sending us data and taking a look at it. And the  
15 licensees are very, very good about making sure we  
16 get the data, we look at it, we get it to our  
17 consultants, they look at it. They want to make sure  
18 that nothing untoward is happening, just like we do.  
19 So, there's a very interactive effort there, in my  
20 experience with working with the licensees as they go  
21 up in power.

22 MEMBER SKILLMAN: So, Tom, for these three  
23 slides, what you're really referring to is the  
24 response of replacement steam dryer for a power  
25 ascension?

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1 MR. SCARBROUGH: Right. That's what this  
2 is talking about, right.

3 MEMBER SKILLMAN: Making sure we're clear.  
4 This is all about an RSD?

5 MR. SCARBROUGH: Right, exactly.

6 MEMBER SKILLMAN: Okay.

7 MR. SCARBROUGH: Okay. And that's -- just  
8 kinda I wanted to give an overview of that and then  
9 you can talk about public comments.

10 MEMBER SKILLMAN: Let me ask my  
11 colleagues, is this a good time to take a ten minute  
12 break? We've been at it for two hours and 40 minutes.  
13 Let's take a ten minute break, please. We are in  
14 recess until 20 minutes after on that clock.

15 (Whereupon, the above-entitled matter  
16 went off the record at 3:06 p.m. and resumed at 3:20  
17 p.m.)

18 MEMBER SKILLMAN: Ladies and gentlemen,  
19 we're back in session, and let us proceed. We were  
20 at the slide addressing public comments. Tom, back  
21 to you, please.

22 MR. SCARBROUGH: Thank you. Are you guys  
23 going to walk us through the public comment slides?

24 MEMBER SKILLMAN: Okay. You can, please.  
25 Go ahead.

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1                   MR. WONG: The NRC received 53 comments  
2                   from Westinghouse, GE Electric, Hitachi, and then  
3                   private individuals. All comments were addressed;  
4                   the comments led to several clarifications of the reg  
5                   guide. The comments were consistent with the intent  
6                   of the revision in that they improved and clarified  
7                   the guidance. The significant comments that led to  
8                   revisions are summarized in the following slides, and  
9                   a full list of the comments and the NRC responses  
10                  were sent to the ACRS. Next slide. The first comment  
11                  was asking to clarify what is background information  
12                  and what is regulatory guidance. The reg guide was  
13                  revised to better distinguish what's background  
14                  information and what's regulatory guidance. The reg  
15                  guide referred to the steam dryer for lessons  
16                  learned, and although these examples are specific to  
17                  the steam dryer, the guidance can be applicable to  
18                  other reactor internal components as well.

19                  The second comment asked to define what  
20                  is high marginal safety, and the revised reg guide  
21                  provides an example of high marginal safety; it says  
22                  a factor of 2.0 for the steam dryer alternating  
23                  stress.

24                  MEMBER RICCARDELLA: Is that a factor of  
25                  2 relative to the code limit, or the fact that the

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1 code limit has a factor of 2 built into that?

2 MR. WONG: Relative to the code limit.

3 Yes.

4 MEMBER RICCARDELLA: That's the  
5 requirement?

6 MR. WONG: That's a guidance for using  
7 the main steam line monitoring method.

8 MEMBER RICCARDELLA: I see. Okay.

9 MR. WONG: This comment asks to provide  
10 guidance to determine the hydro-dynamic loading on a  
11 steam dryer due to water boiling rumbling. The reg  
12 guide was modified to clarify the boiling water  
13 sources and include other internal dynamic forces  
14 which are difficult to quantify. The reg guide  
15 discusses that MPN bench marking can account for any  
16 unaccounted sources. The next comment deals with the  
17 ill-defined boundary conditions. The reg guide was  
18 modified to call for assessment of boundary  
19 conditions variability when that variability leads  
20 to non-negligible response differences. The next  
21 comment deals with CFD validation; the reg guide was  
22 revised to be a little more flexible by replacing the  
23 smallest flow areas with small sole passages. This  
24 comment also deals with CFD validation; similarly,  
25 the reg guide was revised to be less rigid, replacing

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1 maximum passable flow velocity with high local flow  
2 velocity. Next one.

3 This comment requests that low  
4 measurement prediction comparisons should be made  
5 supplemental and not necessary, and the guidance was  
6 revised to clarify that supplemental measurements are  
7 helpful but not always necessary when end to end bench  
8 marking is used. Next one. This guidance asked for  
9 the chemical basis for reducing this fatigue  
10 strength reduction factor from four to three. As  
11 discussed in the structural analysis lessons learned,  
12 the method two provides a level of conservatism  
13 consistent with the ASME codes of section NG  
14 guidance, and the NRC reviewed the parametric studies  
15 of the different cases using method one and two, and  
16 found both methods acceptable.

17 MEMBER RICCARDELLA: So the parametric  
18 studies, they did the model in the conventional way  
19 and used four, and then they modeled the fillet weld  
20 and used three and got the same answer or higher?

21 MR. WONG: The answers are similar.

22 MEMBER RICCARDELLA: Why would anybody go  
23 through all the effort to do the local model then if  
24 you're going to get the same result?

25 MR. WONG: They may have other complex

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1 geometries this kind of alternative method.

2 MEMBER RICCARDELLA: Okay.

3 MR. MORANTE: But I would just like to  
4 add that hopefully people will just go with method  
5 one. We follow the traditional way of handling fillet  
6 welds, because you're right, the extra complication  
7 and complexity of the model seems to be hardly worth  
8 it.

9 MR. WONG: Okay, thanks Rich. The  
10 comment deals with the pre-operational testing at  
11 allowance for specification for no instrumentation  
12 for any new components. The reg guide was revised to  
13 add flexibility to allow for no instrumentation for  
14 new components that have no operating experience.  
15 But the reg guide basically said consider  
16 instrumentation for new components that have no  
17 operating experience, and try to allow flexibility  
18 for the applicant to apply instrumentation. The next  
19 comment, the reg guide discussed the disposition of  
20 fuel samplings during pre-operational testing, and  
21 the comment suggests that the reg guide should  
22 address test configuration and condition as well, and  
23 the reg guide was revised to add the guidance. Next  
24 one. The comment brought up in a situation where one  
25 or two components were replaced, and the FIV effect

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1 on these two components are significant; however,  
2 the effect on the rest of the reactor internal  
3 components are insignificant, and how do we address  
4 the classification and instrumentation of the  
5 reacting internal components? So the reg guide was  
6 revised to add a section to address this specific  
7 situation. Next one.

8 In this comment, it was stating to  
9 perform rigorous statistical analysis for the  
10 theoretically derived forcing function, and the  
11 finite element analysis uncertainties, and the  
12 provocation of the variable uncertainties can be very  
13 difficult, and does not add value to the program.  
14 Most of the uncertainties during the analysis are  
15 addressed by using conservative assumptions, and the  
16 reg guide already mentioned if using end-to-end bench  
17 marking, it can eliminate the need for component-  
18 level bench marking, and to further clarify--to  
19 further address the comment, the section was revised  
20 to mention the acceptable use of conservative  
21 assumption, and not to do the component level bench  
22 marking. This comment point out in the reg guide, in  
23 certain places it used the term peak stress to refer  
24 to total stress, and the reg guide was revised to use  
25 terminology consistent with ASME Subsection NG. The

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1 next one, it mentioned that during pre-operational  
2 testing, the testing results may not always be  
3 conservative without a fuel, and the reg guide was  
4 revised to allow testing without the fuel assemblies  
5 if the test results will yield reasonable results.

6 MEMBER SKILLMAN: How would one know--  
7 how would you know that?

8 MR. WONG: The way the current wording of  
9 the reg guide says, only if the tests results are  
10 conservative bounding the actual plant operation with  
11 the fuel assemblies; otherwise, you cannot run the  
12 pre-operational tests without fuel assemblies. So it  
13 is the wording conservative that may cause problem  
14 for the applicant. So we revised the word to say  
15 reasonable result. If the results are consistent  
16 with the actual plant operation, then the pre-  
17 operational test can be run without the real or dummy  
18 fuel assemblies.

19 MEMBER SKILLMAN: Is that commonly done?

20 MR. WONG: Yes, for pre-operating casts,  
21 if there are no real or dummy fuel assemblies put in  
22 the reactor core to simulate the pressure drop or the  
23 weight, typically people will place flow restricters  
24 in the core to simulate the flow and pressure drop.

25 MEMBER SKILLMAN: Thank you.

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1 MR. SCARBROUGH: Okay.

2 MR. WONG: In the reg guide, it mentioned  
3 an example of a steam dryer failure caused by a  
4 reactor pump ring passing frequency; the comment  
5 pointed out that the root cause for the failure did  
6 not point out the reactor pumping passing frequency  
7 as the sole cause, so the NRC revised the statement  
8 saying the reactor coolant pump passing frequency  
9 may have contributed to the fatigued area. And in  
10 conclusion, the reg guide 120 was revised to simplify  
11 the prototype classifications from eight to three,  
12 address as many lessons learned from EPU and new  
13 reactor applications, ensures a reasonable  
14 applicability to SMRs. The revised reg guide  
15 provides improved guidance to the different high-  
16 frequency excitation mechanisms. The public comments  
17 were addressed and led to several clarifications.  
18 And finally, the reg guide is ready for final  
19 production. That's the conclusion of the  
20 presentation.

21 MEMBER SKILLMAN: Okay, I would like to  
22 ask a couple of questions if I can from my review,  
23 and perhaps my colleagues will have questions from  
24 their review. So let's take some time and go through  
25 these. It would help if you have a copy of the reg

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1 guide.

2 MR. SCARBROUGH: I've got it right here.

3 MEMBER SKILLMAN: If you would look at  
4 the top of page 13.

5 MR. SCARBROUGH: Okay.

6 MEMBER SKILLMAN: The sentence that I'm  
7 going to refer to is the sentence at the top of the  
8 page, and I'll quote that sentence so my comment is  
9 in context. "These mechanisms include vibration  
10 induced by flow turbulence, turbulent buffeting,  
11 acoustic resonance, excitation by separated flow  
12 instabilities, vibration induced by vortex shedding  
13 excitation, and fluid elastic instability. FIV occurs  
14 not only in the lift or normal to the flow direction,  
15 but also in the drag or stream wise direction." Would  
16 you explain lift and stream wise, please?

17 MR. WONG: The lift is the cross flow,  
18 and stream wise is--

19 MEMBER SKILLMAN: In the direction of the  
20 stream? Are those terms thoroughly understood by  
21 users of this reg guide?

22 MR. ZIADA: Hello, Samir Ziada; can I  
23 add?

24 MEMBER SKILLMAN: Please, yes sir. Go  
25 ahead.

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1 MR. ZIADA: Yes, somebody who is doing  
2 flow induced vibrations, they should be familiar with  
3 this, thoroughly understood, and this was added  
4 because of the mentioning about SONGS because the two  
5 vibrated in plane which can be -- refers to the stream  
6 wise, and also because of a problem of thermal couples  
7 in Japan, in a nuclear power plant in Japan, which  
8 has failed due to -- vibration in the steam wise  
9 direction. So it is quite known in the field of flow  
10 induced vibration what is stream wise and cross  
11 stream or the lift. If you think it is not so clear,  
12 we can add clarification for this.

13 MEMBER SKILLMAN: As an experienced nuke  
14 and user of many documents like this, I would be  
15 surprised that others like me might at least pause to  
16 understand what that means. So a footnote or  
17 clarification I think would be valuable.

18 MR. SCARBROUGH: Okay, we can do that.

19 MEMBER SKILLMAN: But this is a  
20 subcommittee, and that's one man's opinion.

21 MR. SCARBROUGH: We can do that, thank  
22 you.

23 MEMBER SKILLMAN: Okay, next comment is  
24 on for document page 16, it's under modes of  
25 vibration, and at 2.1.1.1, the sentence that is my

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1 target for comment is about the third under 2.1.1.1.  
2 "The differences between measured and simulated  
3 natural frequencies are used to establish uncertainty  
4 ranges for FRS and final response calculations. For  
5 example, if benchmarking reveals that the simulated  
6 natural frequencies are within plus or minus 10  
7 percent of those measured, FRS and final responses  
8 are computed over that range of uncertainty." My  
9 question is, what sets, or how do you know that range  
10 of uncertainty? I think you may have touched on this  
11 very gently earlier in the presentation, but this  
12 gets to uncertainties. How do you know? Why pick  
13 that number?

14 MR. HAMBRIC: This is Steve Hambric; I'm  
15 on the phone now. Typically they have a measured  
16 mode shape, a simulated mode shape, and your dasher,  
17 and then you see what the resonance frequencies are  
18 and look at the difference. If you do that for many  
19 modes, you can usually come up with a bracketing  
20 percentage, and your model is plus or minus--accurate  
21 plus five or 10 percent accurate. We just put 10  
22 percent in there as a typical value that if you do  
23 the math -- not necessarily one that has to be used  
24 for all applications.

25 MEMBER SKILLMAN: And I see that the

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1        wording allows for that interpretation, Steve, so I  
2        get it. Thank you. Next comment is on page 17, third  
3        paragraph from the top, and that sentence is "Some  
4        structures might have variable or ill-defined  
5        boundary conditions during normal reactor operating  
6        conditions. When boundary conditions have a more  
7        than minimal effect on component response, their  
8        variability needs to be addressed." Question, how  
9        would one know what is more than minimal? That almost  
10       sounds like enforcement language that we dealt with  
11       out in the field, where more than minimal is someone's  
12       opinion versus if you will a measurement based on a  
13       baseline that we could agree on before we begin our  
14       discussion.

15                MR. SCARBROUGH: Yes, we'll go back and  
16       look at that and come up with some better words,  
17       better than "more than minimal" and try to come up  
18       with some sort of example that would give you more  
19       clarity there. I can understand how that--that's  
20       really open to interpretation. We'll see if we can  
21       add--

22                MEMBER SKILLMAN: One could say  
23       substantial, or what's substantial? More than  
24       minimal? Well, is it less than significant? Those  
25       words are really complex for the implementer.

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1 MR. SCARBROUGH: Right, right.

2 MEMBER SKILLMAN: Thank you. One or two  
3 more comments if I could.

4 MEMBER BLEY: Let me say something on  
5 that one.

6 MEMBER Skillman: Please.

7 MEMBER BLEY: Because the way I  
8 interpreted the discussion I heard from Steve when he  
9 was here was that this is a thing that really needs  
10 to be laid out, looked at and discussed between staff  
11 and the applicant, so whatever your language is, I  
12 don't think we're looking for a bright line, we're  
13 looking for a description of the process.

14 MEMBER SKILLMAN: Bingo.

15 MR. SCARBROUGH: Yes, because that's  
16 exactly true. This is a give and take a lot of times  
17 in terms of what's--

18 MEMBER SKILLMAN: I recognize this is a  
19 negotiation, but it needs to be one of precision where  
20 both sides are able to come to agreement objectively.

21 MR. SCARBROUGH: I agree.

22 MEMBER SKILLMAN: My only point. The  
23 next comment is on page 19, and this has to do with  
24 the topic of lock-on, and Steve mentioned this  
25 earlier. I just simply wanted to suggest the context

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1 of the words on page 19 generally apply to the  
2 replacement steam dryer; in reality, this lock-on  
3 concept can be anywhere. It can be in a P, it can be  
4 in a B, it can be in an SMR, and it kind of raises  
5 the question how do you get out of the lock-on? Once  
6 that lock has occurred, what do you have to do to get  
7 out of it, because they are strong couplings, and for  
8 some reason at least I can't explain, when you try to  
9 back away from the lock-on, it stays locked. It  
10 doesn't want to let go. So I think this concept of  
11 lock-on is important, and there needs to be a  
12 recognition. It isn't just replacement steam dryer  
13 connected. It--lock-on is what happened at Palo  
14 Verde. It locked on, and no matter what they did,  
15 that EKE line, residual E line kept on vibrating and  
16 swaying.

17 MR. SCARBROUGH: Right, and we--you know,  
18 one example is the locking that occurred at Quad  
19 Cities where they ended up changing the stand pipes  
20 for the relief valves drastically, so that you would  
21 get away from that lock-in. And whereas at Dresden,  
22 when they went up in power, they hit the lock-in, but  
23 they still were increasing power, so they still  
24 increased the flow right on through it, so it dropped  
25 back off on them. Whereas Quad Cities, they locked

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1 in, they were sitting right at 116 percent power.  
2 And so yes, we'll go back and look at this and add  
3 more discussion of this concept that applies to more  
4 concurrence.

5 MEMBER SKILLMAN: Thank you. On page 32,  
6 you have a section that is dedicated to guidance for  
7 BWR steam dryers, specific guidance for BWR steam  
8 dryers. Are you inviting the need for special  
9 guidance for pressurized water reactor internals? It  
10 just seems to me that here is this rather overarching  
11 draft regulatory guide; it seems to be somewhat  
12 surgically focused on the steam dryers when in  
13 reality, perhaps there should be specific guidance  
14 for SMRs, there should be specific guidance for PWR  
15 internals, and special guidance for steam dryers, and  
16 I would just observe from my years in the industry  
17 each of those may have a unique set of considerations.  
18 Not problems, considerations, things you might want  
19 to address differently for the differences between  
20 those.

21 MR. SCARBROUGH: You know when we were  
22 looking at this, there was a lot of discussion of  
23 maybe taking the BWR steam dryer discussion and  
24 moving it to an appendix. If we did something like  
25 that, that would make it more possible to have a

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1 different appendix for PWR internals or appendix for  
2 SMRs. I know we've done that with other, like  
3 inspection procedures where we want the focus on MOBs  
4 in one appendix, and air operated valves in another  
5 appendix where we could spend that whole appendix  
6 just talking about that one topic, and not having to  
7 jump back and forth so much. So we could go back and  
8 take a look at this and see if that would be something  
9 where we could, if we have some guidance that we could  
10 put in for PWRs and SMRs, maybe not as detailed for  
11 steam dryers, but to kind of give--start the process  
12 where with the next revision of this a few years from  
13 now, we might have even more guidance for PWRs.

14 MR. LUPOLD: That's a key statement he  
15 just said right there--

16 MEMBER SKILLMAN: I got it.

17 MR. LUPOLD: --is if we have that  
18 additional experience. Right now, this red was based  
19 on the experience we've had since Quad Cities, et  
20 cetera, and the vast majority of it has been steam  
21 dryers. So as we--if we accumulate additional  
22 experience or issues with PWRs, small modular  
23 reactors, learn things about that, and we can add  
24 that in there at that point.

25 MEMBER RICCARDELLA: You know, the lead

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1 in to that paragraph discusses SSEs with no prior  
2 history of adverse effects.

3 MEMBER SKILLMAN: One or two more  
4 comments. I'm on page 33, and this is explaining the  
5 locating of the strain gauges on the main steam lines,  
6 and the sentence is "At least four strain gauges,  
7 evenly spaced around the pipe circumference, are  
8 necessary to filter non-breathing signals." And I  
9 got stumped at non-breathing; is this jargon, or is  
10 this a term that is commonly recognized in the  
11 industry?

12 MR. SCARBROUGH: It's--from the  
13 discussions with Steve Hambric, yes, this is a very  
14 common type of discussion; he's used that terminology  
15 many times in terms of explaining this to me in terms  
16 of--we'll go back and talk to him about if we can add  
17 more language to make it even more clear. But it is  
18 sort of a jargon that his folks use in terms of how-  
19 -

20 MEMBER SKILLMAN: A footnote or a lexicon  
21 or the description of terms of what is it?

22 MR. HAMBRIC: This is Steve, we can spend  
23 a --

24 MEMBER BLEY: Steve, what is it  
25 physically?

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1 MR. HAMBRIC: Oh, it's a hoop motion, the  
2 entire internal --

3 (Simultaneous speaking.)

4 MR. HAMBRIC: -- that's pushing the tie  
5 valve.

6 MEMBER BLEY: Okay I get it. So this is  
7 a circumferential oscillation just simply due to the  
8 internal pressure?

9 MR. HAMBRIC: Yes, the hoop strain.  
10 That's the breathing that we care about; everything  
11 else we don't care about. The steam motion, the  
12 overring, all that gets filtered out.

13 MEMBER SKILLMAN: Thank you. The final  
14 comment that I would make is the comment on the use  
15 of the term internals important to safety; you've  
16 already heard me --

17 (Simultaneous speaking.)

18 MEMBER SKILLMAN: -- and you can find  
19 those very easily on a word search, because they pop  
20 up. And I want to also repeat my comment about a  
21 prototype, becoming a valid prototype to a limited  
22 prototype to a non prototype. I find those confusing;  
23 I would have started with a first of the kind and  
24 then an identical to first of the kind, but my  
25 colleagues and perhaps our consultants might have a

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1 comment or two that any of them may wish to make, so  
2 with that I'm going to halt and allow my colleagues  
3 here to offer any comments they may have before we go  
4 to the public. So colleagues, might any of you have  
5 comments, please?

6 MEMBER BLEY: I'd only add one thing to  
7 what you said. Those early pages that describe  
8 prototype, reference to prototype and not a  
9 prototype, the words didn't bother me, but the  
10 details as we've talked in our discussion is where I  
11 think the problem exists.

12 MR. SCARBROUGH: Yes, we're going to go  
13 back and try to add examples and guidance to help  
14 clarify when you'd be pushed from one to the other,  
15 or what would drive you to be one of those ask opposed  
16 to another one. We're going to go back and look at  
17 that and get our consultants together and come up  
18 with a better language for that, and do a redline  
19 strikeout of that area.

20 MR. MARCH-LEUBA: As invited experts, are  
21 we members of the public, or can we talk?

22 MEMBER SKILLMAN: You are a consultant at  
23 this point, and so we welcome your comments, Dr.  
24 Leuba.

25 MEMBER BLEY: Invited expert.

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1 MEMBER SKILLMAN: Invited expert, I'm  
2 sorry.

3 MR. MARCH-LEUBA: Yes, I'm a paid  
4 consultant, right? Yes, I'm Jose March-Leuba, I'm an  
5 invited expert. I wanted to have--two thoughts.  
6 Number one, I didn't see any discussion on the steam  
7 dryer about steam or liquid carryover on the  
8 calculations, which has a big impact depending on the  
9 conditions, how much leak will you carry over to the  
10 steam line. You always have one, two percent  
11 droplets, which one will imagine will have a big  
12 impact if, I mean--

13 MR. SCARBROUGH: Okay, I will go back and  
14 see if that's covered, and if it's not covered, we'll  
15 add something to talk about that. Thank you.  
16 Carryover effects, okay.

17 MEMBER CORRADINI: Is Steve on the phone?

18 MR. SCARBROUGH: Steve, are you still  
19 there?

20 MR. HAMBRIC: Yes, I'm here.

21 MEMBER CORRADINI: So I think Jose's  
22 point is well taken; I'm wondering does that drive  
23 you to a more conservative calculation or gives you  
24 margin? That's what I was wondering.

25 MR. HAMBRIC: You're talking about like

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1 the water volume fractions?

2 MR. MARCH-LEUBA: Yes, liquid droplets  
3 carried over by the steam that are moving back along  
4 the wall, and they have a lot of mass.

5 MR. HAMBRIC: Oh, on the dryer structure  
6 itself?

7 MR. MARCH-LEUBA: Yes.

8 MR. HAMBRIC: Right, right, right. No,  
9 that would be taken care of with the end to end bias  
10 correction. So they don't model that typically now,  
11 at least I'm not aware that they do, but for some  
12 reason the as-measured stream differed significantly  
13 from the simulated stream that would be carried--  
14 would be taken care of by a bias drill.

15 MR. MARCH-LEUBA: One would expect water  
16 droplets hitting the walls to have a big impact. Of  
17 course, it's only one percent.

18 MR. HAMBRIC: What sort of impact are you  
19 thinking about? Like a damping incident or a--

20 MR. MARCH-LEUBA: When you're raising my  
21 window, the window makes noise.

22 MR. HAMBRIC: Right.

23 MR. MARCH-LEUBA: So, I mean I always  
24 take it to be important.

25 MR. HAMBRIC: So you're talking about a

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1 force of exitation.

2 MR. MARCH-LEUBA: Additional exitation,  
3 correct.

4 MR. HAMBRIC: Right, okay. Yes, that  
5 would be, again, taken care of by the end to end bias  
6 correction, the same way that--the fact that nobody  
7 tries to calculate the boiling water loading, that's  
8 a fluctuating loading of the -- so we can add that to  
9 the sample, along with flowed water that can also be  
10 rain on the roof kind of excitations for water  
11 droplets. Tom, you can take a little note of that,  
12 we can throw that in as part of our discussion.

13 MR. SCARBROUGH: Yes, I got it. Thanks,  
14 Steve.

15 MR. MARCH-LEUBA: And also keep in mind  
16 that the efficiency of the steam separators is  
17 extremely dependent on the flow, so for example if we  
18 were to -- lower flows, there is higher carryover.  
19 So depending on the flow where you operate to, you  
20 will have--instead of one percent, you have two  
21 percent carryover, and you may double the mass of  
22 liquid.

23 MR. SCARBROUGH: Right, so as they go up  
24 in the power ascension, these are factors they would  
25 need to consider, because carry-over would have

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1 changed.

2 MR. MARCH-LEUBA: Because the steam  
3 separators are steam, if you have rubber floors they  
4 don't skid as much, and then they will separate the  
5 steam from the liquid as well. Just the lessons he  
6 has to consider.

7 MR. SCARBROUGH: Right, right. Thank  
8 you. We'll add that.

9 MR. MARCH-LEUBA: And now that you guys  
10 are used to my accent, I'm going to throw a really--  
11 I wasn't going to insult him, but it's something of  
12 a revolutionary concept.

13 MR. SCARBROUGH: Provocative.

14 MR. MARCH-LEUBA: What is the value added  
15 for the staff to review this calculation? Let me  
16 repeat that.

17 MR. SCARBROUGH: Okay.

18 MR. MARCH-LEUBA: This is an extremely  
19 difficult calculation, which frankly, not even Steve  
20 believes the answer to, and then he is going to  
21 require a measurement to confirm that everything  
22 works. What we're doing--the staff is tasked to  
23 protect the safety of the public. The safety of the  
24 public is protected by the experiment, not by the  
25 calculation. By reviewing the calculation, what you

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1 are doing is protecting the investment of the  
2 licensee. The licensee is investing the money and at  
3 risk and saying if I don't pass those tests, I will  
4 have to stop my reactor and do it again. So by  
5 reviewing the calculation, we're not protecting the  
6 safety of the staff or the public. Okay, so I've  
7 been involved in many, many reviews on the NRR side,  
8 but I can see the poor guys from the licensee, they  
9 really don't like those reviews because it has  
10 uncertainty, it has the bring me a rock syndrome, and  
11 a lot of cost and time. One option would be to have  
12 the licensee run it at their own risk. You run the  
13 calculation; I'm not saying don't run the  
14 calculations. You run them, we'll look at them, we'll  
15 look at the results.

16 MR. SCARBROUGH: Okay, I can answer that  
17 question. When we started--when the Quad Cities  
18 event started, we had sort of had that philosophy.  
19 They had their first failure after 90 days, they broke  
20 it apart, they welded it back together, made it  
21 thicker. A few months later, they broke it again,  
22 you know. A few months later, it broke again ---  
23 they kept welding it back together, and kept saying  
24 we'll just weld it back together, right? And  
25 eventually, you know, they decided they were going to

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1 replace the dryer, right, and they did some more  
2 calculations and said we're good to go, right? We're  
3 going to be fine forever, right? And then they shook  
4 their relief valves, so they almost had a double blow  
5 down of Quad Cities, right, on New Year's Eve, right?  
6 Remember that? Where they would have blown down  
7 this rack and probably would have--might have  
8 sympathetically blown down the other rack, right, on  
9 New Year's Eve. So there's a lot of consequences of  
10 looking at the analysis, and when we finally got to  
11 the point our office director NR said that's enough,  
12 that's enough, we're not going to keep relying on--  
13 we've lost confidence in the ability of the licensee  
14 to analyze this problem and ensure their plant is  
15 going to operate safely.

16 And so when we started looking in this  
17 analysis, we brought in Steve and Dr. Ziada and Mr.  
18 Morante to look at all this, and other consultants  
19 we've had from Argonne, Dr. Shaw. We've looked at  
20 the analysis and as we've looked at it, we've found  
21 some significant problems in how they did it. And so  
22 as we went along and when we met again with the NRR  
23 office director, and we told him what was happening  
24 and our concerns, his answer to me was these are not  
25 test reactors. We're not going to start this plant

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1 up and find out what happens. You need to be  
2 confident that their analysis is credible, so when  
3 they get up and power,, they don't want to have the  
4 steam dryer fly apart and go in pieces all down the  
5 steam line, or they're not going to shake their safety  
6 valves apart and blow down their reactor. So that  
7 was a direction that we got, that our job is to have  
8 confidence in the ability of the licensee to analyze  
9 its reactor so it can be operated safely, and the  
10 problem is, it's as you said, it's so complicated  
11 that there's a lot of interaction that needs to take  
12 place to make sure that we're comfortable with what  
13 the licensee is doing, and over the years, we found  
14 a number of places where their analysis was  
15 unacceptable and they had to make corrections.

16 MEMBER CORRADINI: But I think you're  
17 missing his question. His question is the  
18 experimental power ascension is showing adequate  
19 protection; the analysis is investment protection.  
20 That's what I think his point is.

21 MR. MARCH-LEUBA: That is my point.

22 MR. SCARBROUGH: But my marching orders  
23 from my office director at the time was we just can't  
24 run this plant up in power and see if the dryer  
25 breaks; we have to be comfortable before it goes up,

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1 or Scarbrough you're in trouble, right? And so that  
2 was the marching orders that we've had ever since  
3 I've been involved. And so I think what we're doing  
4 here is we're putting down guidance that puts in all  
5 of those years of lessons learned so that when a new  
6 applicant comes in, a new licensee comes in, they can  
7 okay, these are all the things I need to think about.  
8 And one of the things we talked about was for--we  
9 want this reg guide to be sufficiently informative so  
10 that if they follow this reg guide, we won't need to  
11 do all the detailed analysis that you're talking  
12 about that we're doing; that they're going to have  
13 it all here, and they're going to follow through on  
14 this, what it is we've talked about with the new  
15 reactors with tier 2 star.

16 Tier 2 star as you know with ESBWR, that  
17 whole analysis of the steam dryer is tier 2 star,  
18 it's an encyclopedia worth of documents in terms of  
19 how they had to do it. One of the things we talked  
20 about is if they put this reg guide in their ITAAC,  
21 and it's a commitment that they follow this, we won't  
22 make all that encyclopedia tier 2 star. This is what  
23 they have to make sure they follow in the ITAAC. And  
24 so then we would verify that they're following this  
25 as opposed to doing all the detailed analysis that

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1 we've done in the past, that we verify that they're  
2 following the guidance in the reg guide. So that's  
3 some of the things we're thinking about, but I  
4 understand your point, but we need to make sure that  
5 we're comfortable before they start up the power  
6 ascension, to make sure--

7 MEMBER REMPE: But the pull the string a  
8 little further, you said your office director said to  
9 do this; that's not how we usually change things is  
10 it at the NRC? I mean, is that enough that the  
11 director says we will do this, and the staff does  
12 this?

13 MR. SCARBROUGH: If there's a safety  
14 problem, it's yes.

15 MEMBER BLEY: One thing we've seen on  
16 numerous occasions is things that were envisioned as  
17 investment protection; once they happened and we  
18 thought harder about them, they turned into safety  
19 issues, and especially anything that might be parts  
20 of a reactor coolant system.

21 MEMBER STETKAR: And it's certainly true  
22 in the public's perception.

23 MEMBER REMPE: I just am wondering--

24 MEMBER STETKAR: Trying to convince the  
25 public that there's a nuance between something

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1 breaking inside a reactor vessel that is not  
2 important to safety is really difficult, regardless  
3 of what you might think about that. That's why the  
4 public has been so concerned about the steam dryer  
5 issues.

6 MR. MARCH-LEUBA: Yes, but during the  
7 essential testing, you must load methodically and you  
8 stop when your steam gauges tell you you are at 20  
9 percent of limits; you don't break anything.

10 MR. SCARBROUGH: Yes, and we've been  
11 fortunate now the--now Quad Cities, you know, they  
12 got up and were running for 90 days and they blew it  
13 apart, right, and then they tried it again, and this  
14 time they made it six months and then blew it apart.  
15 So they make it up for a while, but they didn't--and  
16 that was the philosophy we had back then.

17 MEMBER RICCARDELLA: They had the  
18 analysis and the strain gauges and all of that when  
19 they were doing this?

20 MR. SCARBROUGH: No. No because it was  
21 completely--

22 MEMBER RICCARDELLA: That's exactly  
23 Jose's point.

24 MR. MARCH-LEUBA: I know a few licensees  
25 that will put 10 times more instrumentation for your

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1 ascension testing, rather than do it on a license  
2 that has to be reviewed.

3 MEMBER CORRADINI: I think that's--just  
4 to repeat the point. The point is if you have an  
5 approved testing program, doesn't that trump the need  
6 to have a detailed analysis? Because when all is  
7 said and done, for safety demonstration, if they have  
8 to do the analysis anyway as part of the testing  
9 program, but yet the experiments or the power  
10 ascension testing with instrumentation is really the  
11 proof of the pudding.

12 MR. ZIADA: Tom, can I add something here  
13 please?

14 MR. SCARBROUGH: Yes, go ahead Samir.

15 MR. ZIADA: If we take the example of  
16 SONGS again. If SONGS had been built according to a  
17 reg guide like this reg guide at one point, most  
18 likely the problem would have been caught during the  
19 design time. First of all, it would have been  
20 classified as a prototype, the largest Mitsubishi  
21 have designed. Second of all, the codes would have  
22 been--must have been validated, which has not  
23 happened, and thirdly, the difference between Unit 1  
24 and Unit 2 with the clearances between the two. They  
25 should have looked at it and it should have shown

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1       that it has no effect. So these three issues are  
2       addressed clearly in reg guide 120, and where they  
3       can put it and test it, but it still is--we can do  
4       anything with it.

5               MEMBER RICCARDELLA: I think the point is  
6       though that the proof of the design isn't just the  
7       testing, it's that the testing validates the  
8       analysis.

9               MR. ZIADA: Correct.

10              MEMBER RICCARDELLA: But still, I think  
11       Jose's point is that well, if the staff were just to  
12       review how well that testing did at validating the  
13       analysis, it probably wouldn't be necessary to  
14       completely also review the details of the analysis.  
15       The real proof is the validation of the analysis by  
16       the testing or by the measurements.

17              MR. MARCH-LEUBA: And now that I have a  
18       little break, let me emphasize that I'm not saying  
19       don't do the analysis; I'm saying don't review the  
20       analysis.

21              MR. SCARBROUGH: Right, and that was sort  
22       of our philosophy after about the third or--up until  
23       the third or fourth Quad Cities failure, and that's  
24       when my direction changed.

25              MEMBER RICCARDELLA: But that's long

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1 behind us now.

2 MR. SCARBROUGH: I know, and we're  
3 getting--that's why we're putting this in here, we're  
4 writing this reg guide, because if they follow this  
5 reg guide, we don't need to do th detailed analysis  
6 anymore, right, because this tells them what's a  
7 reasonable approach and what's acceptable. So that's  
8 why this reg guide is so important to us, is we're  
9 trying to pull in all this lessons learned.

10 MEMBER CORRADINI: So let me say it back  
11 to you; so maybe we misunderstood you. So if they  
12 follow the reg guide, you won't review the analysis,  
13 you'll simply do as suggested, you'll look at the  
14 testing compared to the analysis, but not review the  
15 analysis unless there's some deviation?

16 MR. SCARBROUGH: I don't know who's going  
17 to be in charge of that, but following this is  
18 intended to be acceptable, right, and I don't know  
19 that the staff would just say we never look at  
20 anything that you do, because that's not our job.  
21 Our job is to look at what the licensee presents, but  
22 if they come in and they present that they're  
23 following this and they're following this approach,  
24 I think it's more of a confirming--for confirming  
25 that they're following the reg guide; as opposed to

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1 breaking new ground, we'd be confirming that they're  
2 following the reg guide. So it would be different.  
3 It would be a different type of review, it would be  
4 a confirmatory review as opposed to what we do now,  
5 which is basically making sure every step of the way  
6 is credible.

7 MR. LUPOLD: We would still review the  
8 application and make sure that the licensee is  
9 following the guidance which is in the reg guide, and  
10 if they are using something different than the  
11 guidance, evaluate that. I mean you wouldn't just  
12 say --you wouldn't just accept a statement that says  
13 well, we followed reg guide 1.20, and we said oh okay,  
14 if you did that, then you're fine to go, here's your-  
15 -here's the safety evaluation. We would not do that.

16 MEMBER SKILLMAN: Good. Jose, do you  
17 have any further comments? Dr. Kirchner, do you have  
18 any comment, sir?

19 MR. KIRCHNER: Yes, thank you Chairman.  
20 My concern echoes some of the earlier questioning  
21 about your definitions for prototype and non-  
22 prototype limited, et cetera. What is the  
23 implication across the Commission for use of that  
24 terminology going forward? Is this something that  
25 will be adopted in other reg guides, and I'm thinking

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1 ahead to multiple module plants like the AP-1000 or  
2 the new SMRs coming before you. Is this a new set of  
3 definitions for what is a prototype and a validated  
4 prototype, et cetera?

5 MR. WONG: These different type of  
6 definition have been used in previous revisions of  
7 the reg guide. In revision 4, we simply reduced the  
8 number of different classifications to make it  
9 simpler--

10 MR. KIRCHNER: My question is beyond just  
11 this reg guide, and in terms of using that terminology  
12 elsewhere as the Commission takes up new reactor  
13 designs, et cetera.

14 MR. LUPOLD: Right now there is no  
15 direction to use this in any other application at  
16 this point. We haven't looked at that at this point.

17 MR. SCARBROUGH: Right, this is just for  
18 reactor kernels, just in this application. We're not  
19 trying to define prototype or limited type beyond  
20 just this discussion that we have here.

21 MR. WONG: You mentioned about AP-1000;  
22 AP-1000 uses prototype/non-prototype classification  
23 for their B plan and subsequent plan for the reactor  
24 internals.

25 MR. KIRCHNER: Now secondly, I think Mr.

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1 Lupold already suggested this as a possibility. It  
2 seems to me that there's a lot of good information  
3 here obviously in lessons learned that--I'll use the  
4 word generic; that may not be clinically correct for  
5 PWRs as well as BWRs. Would it not make sense to  
6 pull out the steam dryer issue and put that in an  
7 appendix as you suggested, and then I have a question,  
8 and perhaps this is of ignorance. It seems to me  
9 you're doing a lot of what I would call detailed  
10 design criteria for BWRs based on your lessons  
11 learned. Is this the appropriate place to capture  
12 that, or should it find its way into other guidance?  
13 Specifically, things like not just the dryer, but  
14 based on your experience with these standpipe issues,  
15 is there some generic guidance that you could provide  
16 that says based on experience--I'm not familiar with  
17 the exact dimensions--these stand pipes should be no  
18 more than two feet or half a wavelength or whatever  
19 criteria you want to use to take out this amplifying,  
20 whether it's acoustic or other in the plants.

21 MR. SCARBROUGH: Yes, now we do in the  
22 standard review plan 3.9.2, which is the staff's sort  
23 of generic guidance for this general area, we do  
24 reference back to reg guide 1.20, so we do sort of  
25 pull in this guidance there, and then for the ITAAC

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1 for the new ESBWR, we do have an ITAAC that relates  
2 to the flow through the steam lines to ensure they do  
3 not get these resonances, and they're going to do an  
4 analysis and GH has already been doing that analysis  
5 to show that for their--the steam lines for the ESBWR,  
6 they will not see these resonances. So, but we  
7 haven't looked into putting that guidance in a  
8 different vehicle; that's more design oriented. But  
9 that would be an interesting thing to see--

10 MR. KIRCHNER: That was my feeling. This  
11 is a reg guide for operational testing, not for  
12 designing of the plants.

13 MR. SCARBROUGH: Right.

14 MR. KIRCHNER: But yet you delve into a  
15 lot of detail on the BWR issue, particularly the  
16 dryers and inferred that the driving functions are  
17 coming from X vessel causes. So it strikes me that  
18 that's design criteria, not red guidance for  
19 operational testing.

20 MR. SCARBROUGH: Exactly. That's a good  
21 point. We'll go back and look at that and see if  
22 there is somewhere else also that we can include this.  
23 I'd have to talk to maybe the systems branches and  
24 see what guidance they have in terms of their system  
25 review for steam lines and such, and maybe there's a

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1 way to try to copy this guidance into those documents  
2 to make sure that the new plants are addressing this  
3 for the new reactors and also for maybe SMRs as well.  
4 Thank you.

5 MR. WONG: Yes, the Reg Guide 1.20, the  
6 comprehensive vibration assessment program, it  
7 consists analysis, the stop testing, and later the  
8 assessment of testing results. So this comprehensive  
9 assessment program does include the analysis part.

10 MR. KIRCHNER: No, I understand that. So  
11 it seems to be you're dealing with--yes, I agree, but  
12 it seems to me you're dealing with fundamental design  
13 issues that shouldn't wait for the operational  
14 testing phase.

15 MR. SCARBROUGH: I agree. Thank you.  
16 That's a good suggestion. I'll go back and talk to  
17 the systems branches and see what documents, design  
18 documents they have where we might be able to  
19 incorporate this guidance. Thank you.

20 MEMBER SKILLMAN: I want to thank Jose  
21 and Walter for their comments; I want to ask the other  
22 members if they might have comments. Pete, any  
23 comments to the ?

24 MEMBER RICCARDELLA: Just a philosophical  
25 comment, and I've been working in this industry for

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1 close to 50 years now, and I haven't worked  
2 specifically on BWR steam drivers, but I've worked on  
3 a lot of similar failure problems, operational  
4 failure problems, and it seems like when we have a  
5 problem like that, we focus in on it like a laser.  
6 And we not only solve the problem, we solve it in  
7 spades, you know, and we make sure--and I just wonder  
8 if it would be better served with a somewhat more  
9 balanced approach where we assess the problem, but  
10 then we looked at other areas and brought all these  
11 other things up partially to speed, rather than just  
12 bringing this thing up so much so. And I kind of see  
13 that in here; I don't know how to solve it, but it's  
14 just kind of an observation that I've made through  
15 the years. I don't know if it has any implications  
16 at all on this reg guide, but it's just an  
17 observation.

18 MR. SCARBROUGH: And I understand that,  
19 and actually if you look back at what happened with  
20 the Quad Cities, they kept beefing up the dryer,  
21 beefing up the dryer and making it into a brick, right  
22 you know, it weighs 100,000 pounds, right? It ended  
23 up they put in the acoustics side branches, removed  
24 the resonance at all. That old dryer probably was  
25 fine just the way it was, you know, but they went

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1 through it by beefing up the dryer first rather than  
2 looking at hey what's causing that, and it was the  
3 resonance. And when they put in the side branches,  
4 resonance went away, it flatlined, right? And so  
5 they probably didn't need to replace the dryer.

6 MEMBER BLEY: And it wasn't the resonance  
7 in the dryer, it was the resonance--

8 MR. SCARBROUGH: Yes, it was system. It  
9 was the resonance in the steam line.

10 MEMBER BLEY: It was the system, not the  
11 dryer.

12 MR. SCARBROUGH: Yes, right? And so  
13 that's--and so I agree--

14 MEMBER RICCARDELLA: But yet as we said,  
15 we've put in requirements that are so rigorous that  
16 in effect, every plant that wants to do an EPU ends  
17 up buying and spending the money to buy a new steam  
18 dryer, and is that really necessary?

19 MR. SCARBROUGH: Right, and so if they  
20 went the other way and started looking at their steam  
21 lines, and if they found resonance, they'd be putting  
22 in the acoustic side branches and get the resonance  
23 to go away, maybe their current dryer might be--

24 MEMBER RICCARDELLA: Well aren't there a  
25 lot of EPU plants out there that are operating with

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1       their old dryers? The ones that were approved before  
2       Quad Cities?

3               MR. SCARBROUGH: I guess there are some,  
4       but then I think going up to 16 percent, you know,  
5       the Quad Cities was going up quite high. There were  
6       a lot of lower ones, like five percent or so that  
7       everybody thinks is fine. But yes, there's  
8       definitely ways to look at this and I agree, we're  
9       guilty sometimes of jumping on something and really  
10      piling on when we have a problem. You know, it's  
11      just the way we are.

12             MEMBER SKILLMAN: Well Tom, will the  
13      revised Reg Guide 1.20, which is Rev. 4, give access  
14      to the line of thinking that Pete just described? Is  
15      there an exit route in this revision that would  
16      suggest if the applicant or the owner can demonstrate  
17      that by use of side pipes or standing pipes or other  
18      means, such that the resonances are defeated, that  
19      the dryer might be just fine?

20             MR. SCARBROUGH: Yes.

21             MEMBER SKILLMAN: Is that in there now?

22             MR. SCARBROUGH: There is a discussion of  
23      side branches, things like that, but--

24             MR. HAMBRIC: This is Steve. Let's not--  
25      --that's overly simplifying it. Susquehanna didn't

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1 have that kind of resonance, and it cracked, so  
2 there's other things, too. There's a lot of low  
3 frequency stuff we've been messing with lately, the  
4 reactor recirculation pump down, it's not always the  
5 valve resonance. There's other stuff that hits the  
6 dryers, too, so.

7 MEMBER SKILLMAN: Fair enough. Thank  
8 you, Steve.

9 MR. HAMBRIC: Complicated structures, so  
10 I don't think we can just write everything off because  
11 if we took care of the side branch, everything should  
12 be okay.

13 MEMBER SKILLMAN: Thank you. Good  
14 response. Thank you. Pete, anything else?

15 MEMBER RICCARDELLA: No.

16 MEMBER SKILLMAN: Thank you, Pete. Mike,  
17 anything?

18 MEMBER CORRADINI: Just I had mentioned  
19 before, about some sort of screening suggestions in  
20 the reg guide, but I think you've caught that and you  
21 mentioned it, so--

22 MR. SCARBROUGH: I wrote that down, thank  
23 you.

24 MEMBER SKILLMAN: Thank you. Joy?

25 MEMBER REMPE: Well, to kind of go back

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1 to Pete's comment a little more, and what we briefly  
2 discussed with Browns Ferry, they said the data were  
3 bad, was--and they gave up, and I guess their  
4 application has a replacement steam dryer in it, but  
5 I mean how long was the discussion about well your  
6 data are bad, and what triggered the licensee to  
7 decide oh, they'll just go buy some new steam dryers  
8 for three units?

9 MR. SCARBROUGH: Yes, well I was involved  
10 with Browns Ferry years ago, and they were just  
11 talking, started talking about a replacement or the  
12 power upright. And so it spanned five or six years  
13 of -- so what triggered--can you just answer--do you  
14 know what triggered Browns Ferry to go for a  
15 replacement steam dryer?

16 MEMBER REMPE: Steve did say they had  
17 poor data that they -- lots of noise and things like  
18 that, but why not try and do something else?

19 MEMBER SKILLMAN: Please identify  
20 yourself.

21 PARTICIPANT: The reason why Browns Ferry  
22 withdrew the first application was because the data  
23 was not consistent, and also they did not use  
24 consistent methods in bench marking their  
25 methodology. And then they kept modifying the dryer,

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1 and they were not able to show that it met the  
2 allowable limits. So because it was an existing  
3 dryer, and they couldn't qualify, they finally  
4 withdrew that application. So there were a multiple  
5 number of issues associated with the submittal of the  
6 Browns Ferry application. So then they decided that  
7 they will replace the dryer, and then also change  
8 their contractors. And then they just came back about  
9 a year ago, not quite a year ago, about nine months  
10 ago with the new application, and with new dryers.

11 MEMBER REMPE: Thank you. And I don't  
12 have any other comments.

13 MEMBER SKILLMAN: Thank you. John, any  
14 comments please?

15 MEMBER STETKAR: No sir, nothing.

16 MEMBER SKILLMAN: Thank you, John.  
17 Dennis, comments please.

18 MEMBER BLEY: Nothing additional; I  
19 really got a lot out of today's presentation, thanks.  
20 I think it's a really solid reg guide.

21 MR. SCARBROUGH: Thank you.

22 MEMBER SKILLMAN: Derek, would you make  
23 sure the line is open, please? For the record,  
24 there's no one in the room to make a public comment;  
25 we'll check the phone line for a second here.

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1 Members, please don't scoot, we've got a bit of  
2 business when we close the microphone here, so please  
3 don't leave.

4 DEREK: It's open.

5 MEMBER SKILLMAN: Good afternoon, this is  
6 the ACRS, by chance is anybody from the public on the  
7 line please? If someone is there, would you simply  
8 say hello? Hearing none, thank you. Let's close the  
9 line. Members, the question at hand is are we  
10 satisfied with the reg guide in its current  
11 configuration such that we could write a letter to  
12 NRR saying we do not wish to have further action on  
13 this, or do you think we should bring it to the full  
14 committee for the full committee's consideration, and  
15 then for a full committee letter?

16 MEMBER CORRADINI: I have a question for  
17 the staff. So I need to hear what Tom--his plans  
18 are. Are your plans to make modest, clerical changes  
19 to the reg guide, or substantial changes? You get to  
20 define substantial; I don't want to audit it.

21 MR. SCARBROUGH: What my plan is, we're  
22 going to sit down with the consultants and go over  
23 everything we've heard; we're going to prepare a  
24 redline markup of this and incorporate what we've  
25 heard of your suggestions, and then what we've talked

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1 about was sending it back to Derek, and let you all  
2 take a look at it and see if we've captured  
3 everything. We thought we'd also look at the  
4 transcript and improve it, and then send it back to  
5 you and let you all decide if we've captured your  
6 issues, or if there's additional changes that you all  
7 might want to relay through Derek back to us, and  
8 we'd be happy to incorporate those. Because we're  
9 trying to make it the best possible document, so we  
10 have no problem doing that, and I think that would be  
11 great to improve it that way. So that's my plan.

12 MEMBER BLEY: Point of process. The full  
13 committee could write a letter if we take it to full  
14 committee. We don't do anything, although at a PNP  
15 in the future, we could recommend that the Executive  
16 Director send a memo back, but we don't usually do  
17 that, but we could.

18 MEMBER SKILLMAN: Yes, that's my failure  
19 in being clear with the admin. What I'm really trying  
20 to get to is where do we want to go from here? It  
21 sounds to me like the best thing we should do is to  
22 allow you to amend Rev. 4, do an adjusted Rev 4 and  
23 to allow those of us who did this review to review it  
24 again, and to then make a recommendation to our  
25 colleagues.

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1 MR. SCARBROUGH: Right, that would be  
2 great.

3 MEMBER SKILLMAN: Does that make sense?

4 MEMBER BLEY: Are you saying to have  
5 another subcommittee, or just to read it?

6 MEMBER SKILLMAN: No, just to read it and  
7 caucus among ourselves, and then make a decision what  
8 to do. So I'm clear for the record, here's what I  
9 believe is going to happen. Tom, you and your team  
10 are going to take what you've heard today, and you're  
11 going to spend some time considering what we've  
12 offered, what our consultants have offered. You'll  
13 look at the transcript, and you will amend the present  
14 revision 4. And then you'll send it back to Derek,  
15 and Derek will send it to those of us who have been  
16 involved and ask us members what do you think, what  
17 do we do with it from here? And at that point, we as  
18 the combined subcommittee will make an answer back or  
19 give an answer back to Derek where to go from here.

20 MR. SCARBROUGH: Very good, yes.

21 MEMBER SKILLMAN: Is that what we agreed  
22 to? Does that work? Everybody? We've got a plan.  
23 Tom, thank you very much.

24 MR. SCARBROUGH: Thank you.

25 MEMBER SKILLMAN: Any other comments? We

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1 are adjourned.

2 (Whereupon, the proceedings were  
3 concluded at 4:24 p.m.)  
4  
5  
6  
7  
8  
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# **Regulatory Guide 1.20 “Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Startup Testing”**

**Yuken Wong and Thomas Scarbrough  
US NRC**

**Stephen Hambric, Samir Ziada, and Richard Morante  
Consultants**

**ACRS Subcommittee Briefing  
May 17, 2016**

# Agenda

- Overview of Regulatory Guide (RG)
- Reasons for Revision
- Summary of Revisions
- Specific Lessons Learned
- Public Comments Received and NRC Responses
- Summary and Conclusions

# Overview of RG 1.20

## General Information

- Applicable Regulations
  - 10 CFR 50
    - Appendix A, GDC 1
    - Appendix A, GDC 4
    - Appendix B
- RG 1.20 provides guidance on acceptable methods for developing and implementing a Comprehensive Vibration Assessment Program (CVAP) for reactor internals at nuclear power plants
  - Particular attention is given to avoidance of adverse effects from Flow-Induced Vibration (FIV), Acoustically Induced Vibration (AIV), and Mechanically Induced Vibration (MIV)
- Related Guidance: SRP 3.9.2, “Dynamic Testing and Analysis of Systems, Structures, and Components”

# Overview of the RG

## Technical Issues

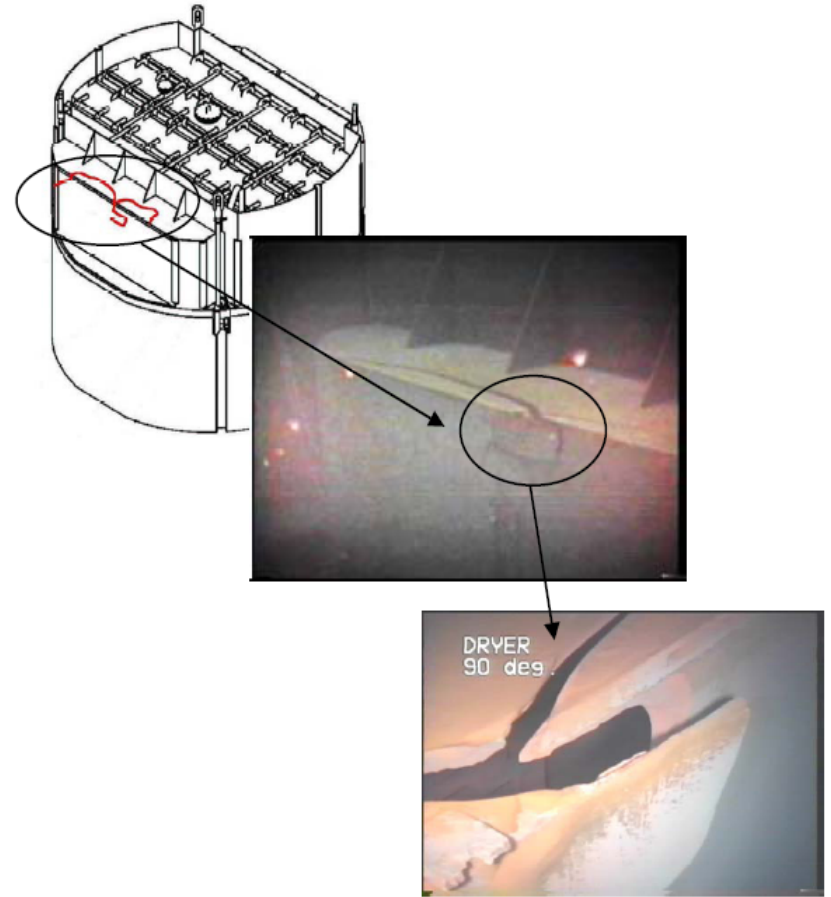
- Guidance on classification of reactor internals as prototypes, limited prototypes, or non-prototypes
  - Considers multi-unit plants/applications
  - Considers individual component replacement
- Analysis procedures
  - Forcing functions (FIV, AIV, MIV)
  - Response modeling, including convergence of stress calculations
  - End-to-end benchmarking
- Measurement procedures
  - In-plant measurement issues

# Reasons for Revision of RG 1.20

- Update prototype definitions
  - Rev. 4 includes only 3 classifications (reduced from 8)
- Reorganize into more concise and useful sections
  - Ensured consistency with organization of revised SRP 3.9.2
- Add numerous lessons learned for analysis and measurement procedures
  - BWR extended power uprate (EPU) applications (steam dryer FIV and AIV)
  - ESBWR Design Certification application (steam dryer)
  - South Texas ABWR Combined License application (steam dryer, and reactor internals)
- Applicability to small modular reactor (SMR) applications
  - Control rod drive mechanisms (CRDMs) might be inside reactor pressure vessel (RPV) module
  - Close proximity of reactor internals and potential interactions

# BWR Steam Dryer Lessons

- Many RG 1.20 improvements are based on lessons learned from BWR EPU and new plant applications involving steam dryer structural integrity
  - Used as examples throughout revised RG
  - Lessons are applicable to other reactor internals
- Minor adjustments to geometry, structural properties, and/or operating conditions can lead to significant changes in structural vibration and alternating stress



# Technical Revision Summary

- Prototype definitions
- Analysis procedures
- Measurement procedures



# Technical Revision

## Prototype Definitions

- Prototype
  - First-of-a-kind or unique design for which no previous “valid prototype” can be referenced
  - Becomes valid prototype after completion of CVAP with no adverse inservice vibration phenomena
- Limited prototype
  - Demonstrate by test or analysis that differences from valid prototype have no significant impact
- Non-prototype
  - Substantially the same arrangement, design, size, and operating conditions as a valid prototype

# Technical Revision

## Key Excitation Mechanisms

- FIV and acoustic resonances produced by fluid flow across or parallel to structural components
- AIV caused by reactor pump pressure pulsation or pressure waves emanating from acoustic resonators such as the standpipes of safety relief valves (SRVs) in main steam lines (MSLs)
- MIV of reactor internals and other structural components caused by structure-borne vibration transmission from reactor recirculation pumps (RRPs) and other machinery

# Technical Revision

## Analysis Procedures

- Structural, Hydraulic, and Acoustic Modeling
  - Modes of Vibration
  - Structural Damping
  - Frequency Response Functions
- Forcing Functions
  - Flow Excitation with Feedback and Lock-In Mechanisms
  - Scale Model Testing (SMT)
  - Computational Fluid Dynamics (CFD) Modeling
  - Force Inference Approaches
  - Mechanical and Acoustic Forces from RRP's

# Technical Revision

## Analysis Procedures (continued)

- Computing and Benchmarking Structural and Acoustic Operational Response
  - Benchmarking of Overall (End-to-End) Computed Response
  - Stress Convergence and High-Cycle Fatigue Evaluation
  - Operational Vibration and Stress Acceptance Criteria
- Preoperational and Testing Analysis

# Technical Revision

## Measurement Procedures

- Specific guidance for BWR steam dryers
- In-plant measurement issues
- Vibration measurement program documentation
  - Instrumentation and data acquisition
  - Preoperational and power ascension test plans
  - Acceptance criteria
  - Test duration and conditions
- Inspection criteria

# Technical Revision

## Limited and non-Prototype

- Simplified analysis and measurement sections
- Applicants reminded that seemingly minor changes in geometry or operating conditions can lead to significant increases in FIV, MIV or AIV
  - Testing and analyses needed, but reduced in scope
  - Case by case evaluations by staff

# Technical Revision

## Specific Lessons Learned

- Excitation mechanisms
- Structural modeling
- Acoustic modeling
- Forcing functions
- SMT
- End-to-end benchmarking
- Structural stress modeling
- Instrumentation
- In-plant measurements
- Power ascension

# Technical Revision

## Specific Lessons Learned: Excitation Mechanisms

- Relevant Excitation Mechanisms for Dynamic Analysis
  - Not well defined in Revision 3 of RG 1.20
  - Operational experience with acoustic resonances of valves on main steam lines
  - Operational experience of structural failure that may have been due to RRP excitation at the vane passing frequency
  - ➔ *Brief introduction of mechanisms (FIV, AR, AIV and MIV)*
  - ➔ *Flow excitation by various oscillation modes of shear layers*
  - ➔ *Resonance of the acoustic trapped modes inside main steam isolation valves (MSIVs)*
  - ➔ *Boiling water excitation of the immersed lower portion (skirt) of BWR steam dryer (included in end-to-end benchmarking)*



# Technical Revision

## Specific Lessons Learned: Structural modeling (1/3)

- Structural Modes
  - Previous application materials show differences between as-modeled and as-measured modal frequencies and mode shapes
  - Used to establish uncertainty in structural modeling resonance frequencies
  - ➔ *Forcing functions should be compressed and expanded in frequency to span uncertainty (+/-10% has been acceptable in past applications)*
  - ➔ *Force inference procedures which combine measured response and modes from models need to properly account for uncertainty in resonance frequencies*

# Technical Revision

## Specific Lessons Learned: Structural modeling (2/3)

- Structural Damping

- Rayleigh damping is commonly used for time-domain structural analysis. Some applications chose anchor frequencies either:
  - Above a strong low frequency forcing function
  - Below a strong high frequency forcing function
- ➡ *Anchor frequencies must be chosen to ensure conservative response are calculated at peak loading frequencies*
- Some applications have applied additional damping due to hydrodynamic viscous effects (perforated plates, for example)
- ➡ *Acceptable when substantiated and validated*

# Technical Revision

## Specific Lessons Learned: Structural modeling (3/3)

- Documentation and Justification
  - Previous steam dryer EPU applications initially provided incomplete or inadequate documentation and benchmarking of vibration and stress calculation methodologies
  - Also, previous applications showed sometimes significant differences between as-designed and final as-built conditions and final alternating stresses
  - ➡ *A more formalized and rigorous documentation and justification of procedures is therefore warranted*

# Technical Revision

## Specific Lessons Learned: Acoustic modeling

- Acoustic models are often used to calculate structural loading distributions
  - Previous applications have initially provided inaccurate modelling of acoustic properties, sound wave spatial discretization, and nozzle areas
  - ➡ *Acoustic properties (sound speed, mass density, damping) may be adjusted during benchmarking, but must not deviate excessively from physically justified values*
  - ➡ *Spatial discretization must be at least 6 elements/acoustic wavelength*
  - ➡ *Circular nozzle areas must be properly represented in discretized meshes*

# Technical Revision

## Specific Lessons Learned: Forcing Functions (1/3)

- Bounding Expressions of Forcing Functions
  - Number and arrangement of operating pumps can vary resulting in biased flow distribution inside RPV
    - ➔ *Use the reactor flow distribution which results in the highest possible local flow velocities*
  - Dynamic response of reactor internals depends on the phase distribution and the correlation length of fluid forces
    - ➔ *Use conservative simplifications and approximations to ensure that forcing functions are bounding*
  - Some initial applications extrapolated resonance amplitude from response over an excessively wide frequency range
    - ➔ *Use a narrow frequency band centered around the resonance peak to estimate the growth rate of resonances*

# Technical Revision

## Specific Lessons Learned: Forcing Functions (2/3)

- Effect of Geometry Details
  - Some self-excitation mechanisms can be affected strongly by small changes in geometry:
    - sharpness of a corner at flow separation
    - length or diameter of the standpipe of a SRV
    - clearances at structure supports
    - revolution per minute (RPM) of RRP
  - ➡ *CFD and SMT models must be accurate replicas*
  - ➡ *Analyze the effects of individual changes and the cumulative effects of all deviations from previous successful design*
  - ➡ *Analyze components which are similar in design but larger in size than a previous successful design*
  - ➡ *Analyze effect of changes in the RPM of RRP*

# Technical Revision

## Specific Lessons Learned: Forcing Functions (3/3)

- Numerical Simulations

- CFD codes are often used to estimate flow velocities which are used to estimate forcing functions
- Although presently not common, CFD techniques may in the future assist in developing forcing functions
- Boundary conditions in numerical simulations (acoustic, hydrodynamic or structural) are often variable or ill-defined. This needs conservative assumptions to produce bounding response

- ➡ *All simulation codes must be validated on systems which are similar to the plant components in both geometrical complexity and flow regime*
- ➡ *Use feasible boundary conditions which result in bounding dynamic response*

# Technical Revision

## Specific Lessons Learned: Scale Model Testing (1/3)

- Dynamic Similitude

- Previous applications used SMTs to estimate forcing functions

- ➔ *Ensure dynamic similitude of the SMTs:*

- *Mach number for flow-acoustic coupling, and fluid-elastic parameter for fluid-structure interaction*
    - ***Only conservative*** *distortions of model parameters are acceptable*

- Effect of Reynolds Number (Re)

- The Reynolds number is much lower in SMT than in plants
  - Previous SMT showed results dependence on Re
  - ➔ *Demonstrate that the SMT results are not influenced by further increases in the Reynolds number*



# Technical Revision

## Specific Lessons Learned: Scale Model Testing (2/3)

- Effect of Transient Test Conditions
  - SMTs are often performed at transient test conditions (variable pressure, temperature, and velocity)
  - SMT results are very sensitive to variations in test conditions
  - Measured resonance peaks become wide and weaker
  - ➔ *Perform multiple test runs at the same test conditions to obtain reliable SMT results with reasonable uncertainties*
  - ➔ *Perform sample size sensitivity analyses to ensure bounding estimate of the forcing functions*

# Technical Revision

## Specific Lessons Learned: Scale Model Testing (3/3)

- Bump-Up Factor (BUF)
  - The **ratio** between the dynamic loading at a power level to that measured at a lower power level
  - Obtained from SMT and used to estimate in-plant forcing functions from in-plant measurements at lower power levels
  - Found to be frequency and location dependent
  - Uncertainties in transient tests can cause BUF underestimates
  - ➔ *BUFs must be validated with plant test data*
  - ➔ *Increase range of SMT to provide margin against uncertainties in test conditions*
  - ➔ *BUF cannot be less than the square of flow velocity ratio*

# Technical Revision

## Specific Lessons Learned: End-to-end benchmarking

- Benchmarking: previous applications have benchmarked individual component of the analysis procedure, and combined their bias error corrections and uncertainties (B/U) using square root sum of the squares (SRSS)
  - Such an approach assumes that all forcing function and response mechanisms are included in the analysis procedure
    - Not always true (as learned from steam dryer experiences)
  - ➡ *End-to-end benchmarking is preferable*
    - *On-structure vibration and strain measurements include all sources and response mechanisms*
    - *Single B/U captures any neglected sources or erroneous response modeling*

# Technical Revision

## Specific Lessons Learned: Structural Stress Calculations (1/3)

- Structural Stress Procedures

### ASME BP&V Code Section III, Subsection NG

- Provides stress and fatigue limits for core support structures; adopted for nonsafety-related BWR steam dryers to preclude loose parts generation
- Limits on primary stress, primary + secondary stress, and fatigue due to cyclic loading all need to be satisfied
- Due to high frequency excitation mechanisms, the potential for high cycle fatigue must be evaluated, requiring conservative estimates of local stress concentrations, such as at fillet welds
- ➔ *Detailed guidelines for structural analysis included in RG; ensure convergence of stress solution through successive mesh refinement*

# Technical Revision

## Specific Lessons Learned: Structural Stress Calculations (2/3)

- Analysis Procedures
  - The input time step and model mesh refinement for the structural analysis must be short enough and fine enough, respectively, to capture both rapid time variations and spatial variations of the dynamic input
  - Structural model meshes and surface loading model meshes are nearly always different
  - ➡ *Solution time step should be no larger than 0.125 times the shortest period of interest (e.g., 0.0005 sec. for 250 Hz)*
  - ➡ *The input time increment may be no larger than 0.25 times the shortest period of interest, with 0.125 times preferred*
  - ➡ *Checks on the load mapping of localized loading distributions, particularly in areas of expected high stress, need to be conducted*

# Technical Revision

## Specific Lessons Learned: Structural Stress Calculations (3/3)

- Weld Stress Concentrations

- Follow the fatigue evaluation procedures and acceptance criteria of ASME B&PV Code, Section III, Subsection NG, for fillet welds
- Stress concentration factors needed to ensure reasonable estimates of total stress (primary+secondary+peak) for fatigue evaluation of fillet welds
- ➡ *Two acceptable methods described*
  - ➡ *1. Four times the nominal stress at the juncture in a global model without fillet details*
  - ➡ *2. Three times the linearized stress on the throat of the fillet in a submodel analysis with nominal fillet geometry included*

# Technical Revision

## Specific Lessons Learned: Instrumentation (1/2)

- Measurement locations
  - Selection of measurement locations which are well correlated to peak vibration and stress regions ensures rigorous monitoring of a structure's actual condition during power ascension
  - ➡ *Accelerometers need to be placed at or near predicted peak response locations*
  - ➡ *Strain gages need to be placed at or near locations with predicted minimum gradients in strain*
  - ➡ *Coherence needs to be maximized between sensor and critical response locations*

# Technical Revision

## Specific Lessons Learned: Instrumentation (2/2)

- MSL Strain Gage Arrays
  - Internal pressures inferred from hoop strain measurements
  - Past applicants have reported difficulties measuring repeatable MSL hoop strains within the same plant, or between plants
    - Sensor failures, background noise problems, and operator error have all led to erroneous loading estimates
  - ➔ *At least four working gages around circumference needed (more preferred for risk mitigation if some sensors fail)*
  - ➔ *Static pressurization calibration recommended*
  - ➔ *Updated measurements needed before power ascension*



# Technical Revision

## Specific Lessons Learned: In-plant measurements (1/2)

- Previously submitted measurements have been unacceptable
  - Q/A issues (wrong sensor channels, improper calibrations)
  - Poor data quality (high Electromagnetic Interference [EMI], unexplained data corruption)
  - ➔ *General in-plant measurement guidance provided*
    - ➔ *Instrumentation need to function properly in plant*
    - ➔ *As-welded strain gage calibrations needed, periodic shunt recalibration recommended*
    - ➔ *Instruments/cabling should be far from high EMI regions*
    - ➔ *Data acquisition systems should be calibrated*

# Technical Revision

## Specific Lessons Learned: In-plant measurements (2/2)

- Noise reduction methods
  - Electrical tones (60 Hz multiples, RRP drive frequencies) often add noise to measured data
  - All measurement systems have a broad-band noise floor
  - ➡ *Noise reduction techniques acceptable provided they do not lead to excessive signal reduction and unreasonable data*
  - ➡ *Notch filtering to remove electrical tones should be used with care, perhaps with 'backfilling' of averaged signal*
  - ➡ *Coherence processing and wavelet noise reduction acceptable but must be substantiated*
  - ➡ *Use same noise reduction method in benchmarking and during power ascension measurements*

# Technical Revision

## Specific Lessons Learned: Power Ascension (1/3)

- Power ascension limits
  - Sensors, instrumentation wiring, data acquisition systems, and reactor response may change slightly over time due to aging and other effects
  - Root mean square (RMS) and/or frequency-dependent limits may be used
  - ➔ *Since limits are based on relative differences between a base state and future condition, they should be updated prior to power ascension*
  - ➔ *If peak or RMS limits are used:*
    - (a) *Use sufficient number and type of sensors and locations*
    - (b) *Ensure all important resonance and forcing function frequency peaks are bounded*

# Technical Revision

## Specific Lessons Learned: Power Ascension (2/3)

- Limit violations and reanalyses
  - Full structural reanalyses are time consuming, and often impractical during power ascension
    - Monitoring sensors have finite lives
  - ➡ *Reanalysis may be performed using approximate methods that have been shown to be reasonable and conservative in previous benchmarking*
  - ➡ *Final structural analysis after completion of power ascension should be conducted using full analysis procedures*

# Technical Revision

## Specific Lessons Learned: Power Ascension (3/3)

- Acceptance limit updating and trending
  - Acceptance limits are updated at each power ascension level
  - Responses are projected to full power level using trending analysis and compared to acceptance limits
  - ➡ *Trending must be based on data at several lower power levels*
  - ➡ *For coupled resonance behavior, trending needs to apply conservative functions to ensure worst-case response at higher power levels is adequately bounded*

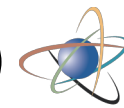
# Addressing Public Comments

## and NRC Responses

- 53 Comments received from:
  - Westinghouse
  - General Electric – Hitachi
  - Private individual
- All comments addressed
  - Comments led to several clarifications of draft RG revision
  - Comments consistent with intent of revisions: improve and clarify guidance for reactor internal CVAP
- Significant comments (those that led to revisions) summarized on following slides with NRC responses
  - All public comments and NRC responses provided prior to meeting

	Public Comment	NRC Response
<b>Guidance vs background</b>	It is often unclear what text is background information vs. expectations for a predictive analysis, measurement program, or inspection program. Rework the document to <u>clearly define the regulatory expectations for a CVAP separately from background or lessons- learned information.</u>	The RG was revised to <u>better distinguish background information from regulatory guidance.</u> “Reason for Revision” section of RG includes statement to clarify that much of the revised guidance uses steam dryer lessons learned as examples. Although these examples are specific to dryers, the guidance is applicable to all nuclear power plant internals.
<b>Safety Margin</b>	In Section C.1.4, define “ <u>high margin of safety.</u> ”	An example of what the staff considers <u>to be a high margin of safety was included</u> (e.g., a margin of safety of 2.0 in the steam dryer alternating stresses).

# Public Comments & NRC Response (2/10)



**U.S. NRC**

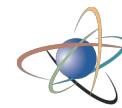
United States Nuclear Regulatory Commission

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	Public Comment	NRC Response
<b>Excitation by boiling water</b>	In Section C.2.a, provide guidance on the approach to be utilized to determine the <u>hydrodynamic loading on the steam dryer due to “boiling water rumbling.”</u>	<u>The sentence was modified to clarify the boiling water sources, and include other internal dynamic forces which are difficult to quantify.</u> Additional guidance for difficult-to-quantify internal forces is provided in Section C.2.1.3 which advocates using end-to-end benchmarking of on-structure measurements so that bias errors can be used to account for any unaccounted sources.
<b>Boundary conditions</b>	Section C.2.1.1, last paragraph should be reworded to indicate that <u>“ill-defined boundary conditions”</u> should be evaluated where they have a <u>significant impact on the response of the component</u> . In some case, test data shows that installation/assembly does not affect the frequency response of the component.	<u>The sentence was modified to call for assessment of boundary condition variability when that variability leads to non-negligible response differences,</u> not only “significant” response differences.



# Public Comments & NRC Response (3/10)



**U.S. NRC**

United States Nuclear Regulatory Commission

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	Public Comment	NRC Response
CFD validation	<p>In Section C.2.1.2, Subheading “CFD Modeling,” Paragraph “b,” reword to replace “including proper definitions and representations of the smallest flow areas” with more <u>general guidance to appropriately consider the effect of small flow passages</u>. Rephrase the statement to provide general guidance to use sound judgment and provide validation where necessary in CFD modeling.</p>	<p><u>This section was revised to replace “the smallest flow areas” with “small flow passages.”</u> No changes, however, were made regarding CFD validation because this issue is addressed in Paragraph “a.”</p>
CFD validation	<p>In Section C.2.1.2, Subheading “CFD Modeling,” Paragraph “c”: The term “local velocity” is ambiguous, and could be misinterpreted. Further, depending on circumstances, higher local velocities may not result in more limiting flow-induced loads. Recommend <u>rewording the guidance to ensure effects such as high local velocities are appropriately considered</u>.</p>	<p><u>This section was revised to replace “the maximum possible flow velocity” with “high local velocities.”</u> No other changes however were made since Paragraph “c” does not state that more limiting flow-induced loads result from higher local velocities. Instead, it states that high local flow velocities need to be taken into account.</p>

	Public Comment	NRC Response
<b>End-to-end Benchmarking</b>	In Section C.2.1.3, Subheading, “Benchmarking of Overall (End-to-End) Computed Response,” first paragraph, modify the guidance to “validate the simulation of intermediate quantities, such as loads....” to reflect that the <u>load measurement/prediction comparisons are supplemental and are not necessary</u> .	<u>The sentence was modified to clarify that the supplemental measurements are helpful, but not always necessary when end-to-end benchmarking is used.</u>

	Public Comment	NRC Response
Stress Analysis of Fillet Welds	<p>Section C.2.1.3, Subheading “Stress Convergence and High-Cycle Fatigue Evaluation,” paragraph “c”: Method 2 – <u>Is there justification</u> (e.g., publication or test data) <u>that supports reducing the weld fatigue strength reduction factor (FSRF) from 4 to 3?</u></p> <p>This is not consistent with ASME Code, Section III, subsection NG.</p>	<p><u>Method 2 provides a level of conservatism consistent with the guidance in ASME BPV Code Section III, Subsection NG</u>, and is acceptable to NRC for calculating the alternating stress for two-sided fillet welds. In Method 2, the nominal geometry of the fillet weld is explicitly modeled using solid elements. The value of the linearized, converged stress on the throat, taken at the root, and multiplied by 3, provides alternating stress predictions for fatigue analysis that are consistent with Method 1. This was determined by parametric study of both Method 1 and Method 2.</p>

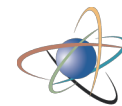
# Public Comments & NRC Response (6/10)

	Public Comment	NRC Response
Component Instrumentation	In Section C.2.2, first paragraph, revise “Instrumentation will be needed for new components that have no operating experience” to <u>add allowance for justification for no instrumentation for this new component.</u>	<u>The statement was revised to enable flexibility for the instrumentation of new components that have no operating experience.</u>
Test Configuration and Condition	Section C.2.2.3, paragraph “e” only discusses fuel assemblies, but should be generalized to address all significant differences between the <u>CVAP test configuration and conditions</u> and normal operating configuration and conditions.	<u>The paragraph was expanded to address test configuration and conditions.</u>

# Public Comments & NRC Response (7/10)

	Public Comment	NRC Response
Component Modification	<p>The paragraph on page 9 of Section C.1.2 did not address the <u>situation where only one or two components change and the rest of the components remain the same</u> as the prototype. The changes may have significant effect on these one or two components but not on the others. Will the entire reactor internal assembly be classified as prototype because it cannot be demonstrated that there is no effect on all components?</p>	<p>The introduction to Section C.1 was expanded to clarify the differences between the full reactor internals and individual components. Additionally, <u>a new Subsection 1.5, “Special Considerations for Replacement / Modification of Individual Reactor Internal Components” was added to address individual component replacement / modification.</u></p>

# Public Comments & NRC Response (8/10)



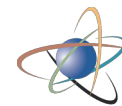
**U.S. NRC**

United States Nuclear Regulatory Commission

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	Public Comment	NRC Response
<b>Bias and Uncertainties</b>	<p>Using Section C.2.1.3, fourth paragraph as an example. At many places, addressing bias and uncertainty is required. Even though determining the uncertainty of the experimentally collected data can be done, performing rigorous statistical analysis for the theoretically derived forcing function and the finite element analysis uncertainties and the propagation of the variable uncertainties can be very difficult and does not add value to the program. <u>Most of the uncertainties during the analysis are addressed by using conservative assumptions.</u></p>	<p>Paragraph 5 of the Background section in Section B, "Discussion" already provides a general summary of acceptable methods for determining bias errors and uncertainties, along with the benefits of end-to-end benchmarking which can eliminate the need for cumbersome component-level benchmarking. To further clarify the discussion, <u>this section was revised to mention the acceptable use of conservative assumptions</u> (provided they are substantiated).</p>

# Public Comments & NRC Response (9/10)



**U.S. NRC**

United States Nuclear Regulatory Commission

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	Public Comment	NRC Response
<b>Stress Terminology</b>	Using Section 2.1.3, Subheading “Stress Convergence and High-Cycle Fatigue Evaluation,” paragraph “c” as an example. Throughout the RG, <u>the term "peak stress" has been misused to refer to "total stress."</u> Refer to NG-3213.10 and NG-3213.13 for the definitions of peak stress and total stress.	<u>The stress terminologies were revised</u> as necessary to be consistent with the ASME BPV Code Subsection NG terminologies.
<b>Fuel Assembly Disposition</b>	Section C.2.2.3, paragraph “e” does allow conducting the test without the dummy fuel if it is justified that such condition will yield conservative results. However, <u>the conservative results may not always be achieved without the fuel</u> due to many factors that affect the final response such as the flow rate, structural frequency and temperature. Higher flow rate or lower temperature may not lead to conservative stresses due to the structural frequency aspect of the analysis.	This section was revised to allow testing without real or dummy fuel assemblies if it is justified by analytical or experimental means such that <u>the test condition will yield reasonable results.</u>

# Public Comments & NRC Response (10/10)

	Public Comment	NRC Response
Reactor Pump Vibration	In Section B and Section C.2(c) the statement about studies of past failures have determined that the steam dryer in a BWR plant experienced fatigue failure caused by vibration transmission from the reactor pumps at the vane pass frequency (VPF) is misleading because <u>it was not conclusive that the reactor pump VPF vibrations were the sole cause of the failure.</u>	The RG sections were modified to state that <u>the reactor recirculation pump VPF tones may have contributed to the fatigue failure.</u>



# Summary and Conclusions

- RG 1.20 revised
  - Simplifies prototype classifications
  - Addresses many lessons learned from EPU and new reactor applications
  - Ensures reasonable applicability to SMR applications
- Revised RG provides improved guidance to ensure structural integrity of reactor internals subjected to FIV, AIV, and MIV
- Public comments received and addressed
  - Westinghouse, GEH, and private individual provided comments
  - Several clarifications made to the draft RG revision based on public comments
- RG 1.20 Rev. 4 ready for final publication

# **Backup Slides**

**RG 1.20**

**ACRS Subcommittee Briefing**

**May 17, 2016**

# Overview of NRC RGs

- RGs identify one or more method(s) that the NRC has determined to be acceptable (but not required)
- RGs do not impose requirements
- Applicants are free to use an alternative method, provided that they demonstrate to the NRC that the selected method satisfies applicable regulations
- Use of RGs by applicants conserves staff resources and simplifies licensing because the guides identify methods that the staff has already determined to be an acceptable approach to meeting the regulations

# RG Revision Process/Timeline

Draft RG Issued for Public Comment in Federal Register	July 2, 2015
Initial Comment Period Response Date	August 31, 2015
Total 53 Comments Received	
Westinghouse Comments Received	August 26, 2015
GEH Comments Received	August 31, 2015
Jianfeng Yang Comments Received	August 31, 2015
Public Comments Addressed and RG finalized	December 25, 2015
RG Issued to NRO/NRR for Concurrence Review	March 21, 2016
OGC Preliminary Review	April 7, 2016
ACRS Subcommittee Review	May 17, 2016
Incorporate Any ACRS Recommendations (TLs)	
OGC Review for NLO (Usually 2-weeks)	
Publish on the FR (Approximately 1- week)	

# Technical Revision Details

## Prototype Definitions - continued

- Multi-unit plants
  - Prototypes, limited prototypes, and non-prototypes for multi-unit plants on a single site or for a standard design at multiple sites
- Individual component replacement
  - Same definitions apply for individual components
  - Show that component replacement will not significantly affect other components

# Technical Revision Details

## Examples of Internals - BWRs

- Chimney and partitions
- Chimney head and steam separator assembly
- Steam dryer assembly
- Feedwater spargers
- Standby liquid control header, spargers, and piping
- RPV vent assembly
- Core plate
- Top guide
- Control rod drive housing and guide tube
- Orificed fuel support
- Jet pump and support
- Shroud and shroud support
- Core plate and reactor pump differential pressure lines
- in-core monitoring housing system/in-core guide tubes and stabilizers

# Technical Revision Details

## Examples of Internals - PWRs

- Core barrel
- Upper core support assembly
- Lower core support assembly
- Control rod guide assembly
- In-core instrumentation guide tubes
- Flow distribution device
- Heavy reflector
- Irradiation specimen baskets

Although this regulatory guide applies to reactor internals, it provides guidance that could be helpful for the evaluation of potential adverse flow effects on steam generator (SG) internals and tubes in PWRs

# Technical Revision Details

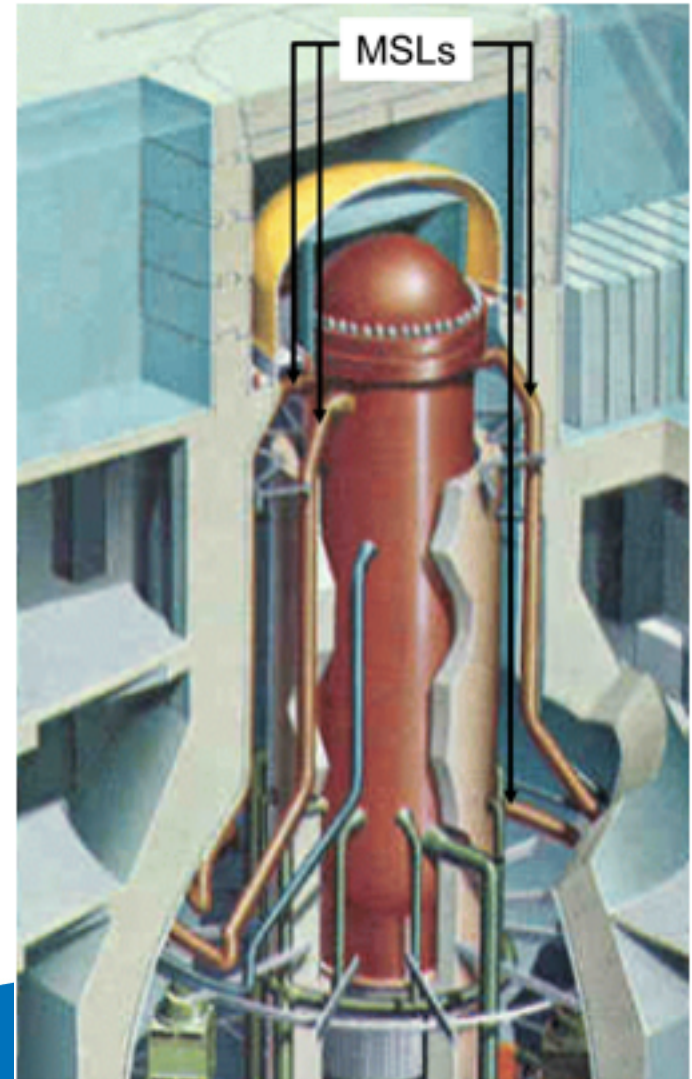
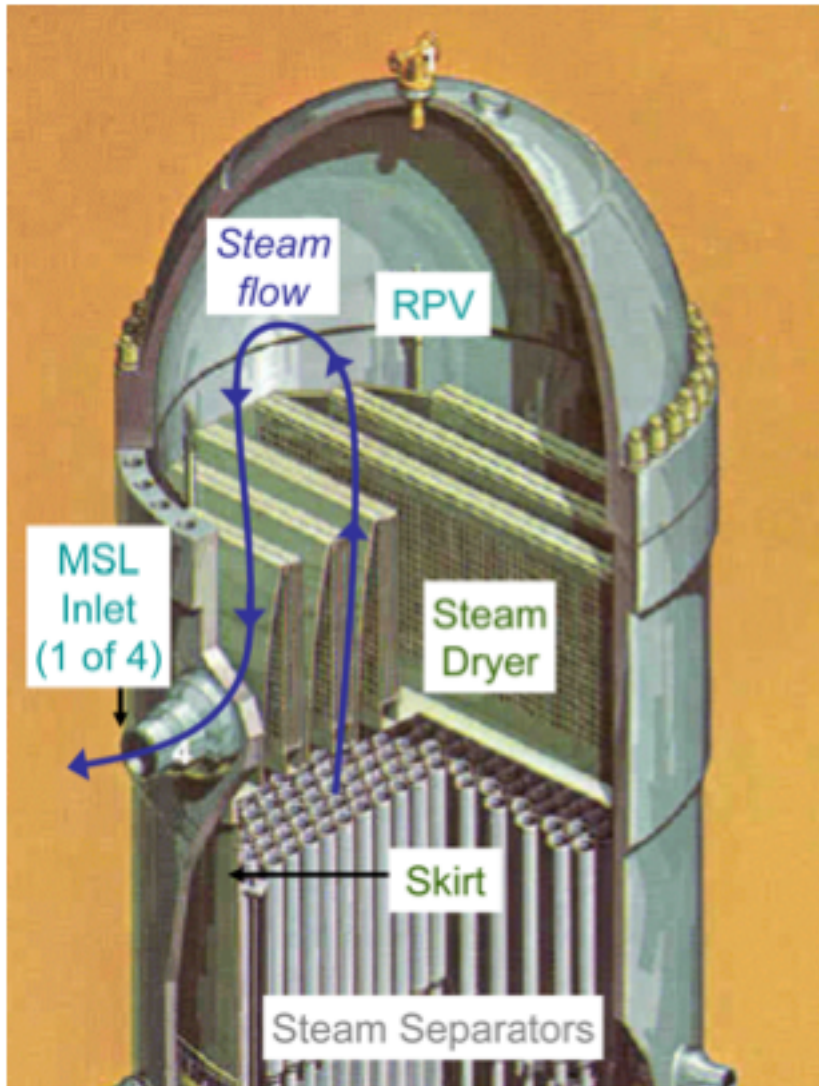
## Examples of Internals - SMRs

For SMRs, reactor internals might include the following additional components because of their location inside the integral RPV module, even though some components might not be traditionally classified as reactor internals:

- Reactor Recirculation Pumps (RRPs)
- Riser
- SGs
- Pressurizer
- CRDMs and supports
- Feedwater lines

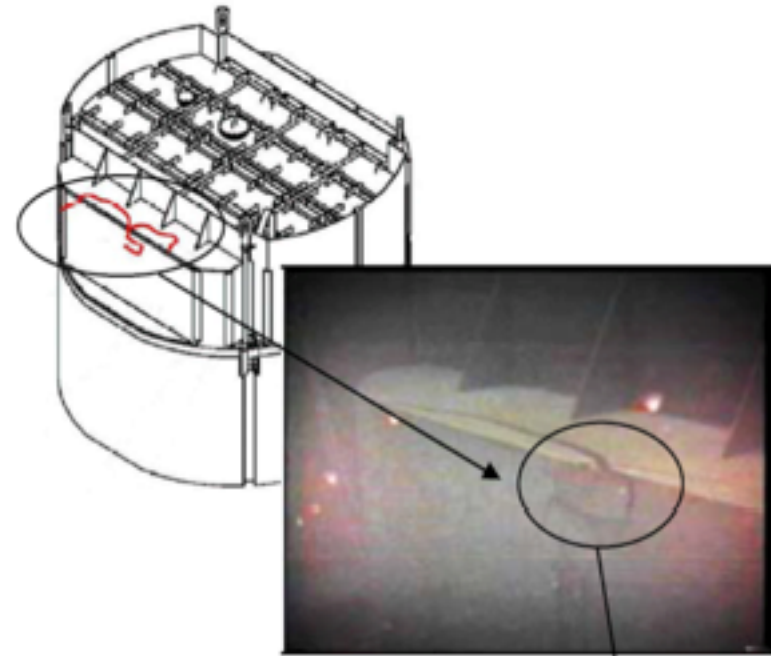
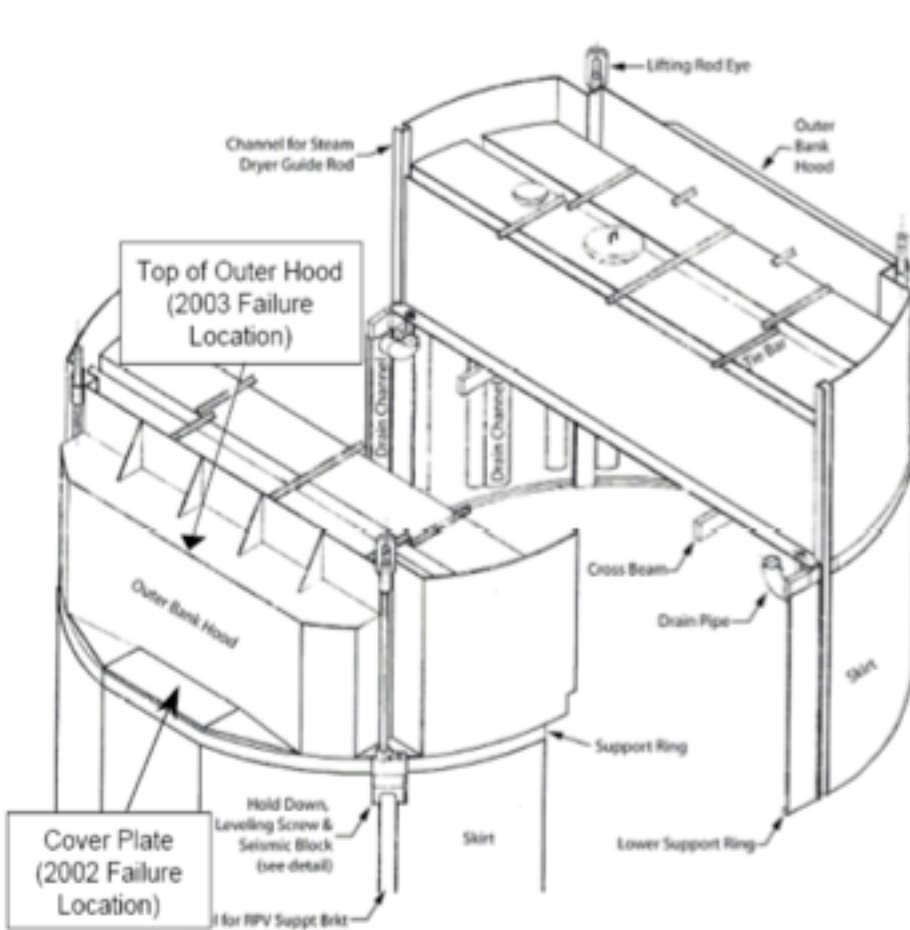


# BWR Steam Dryer FIV and AIV



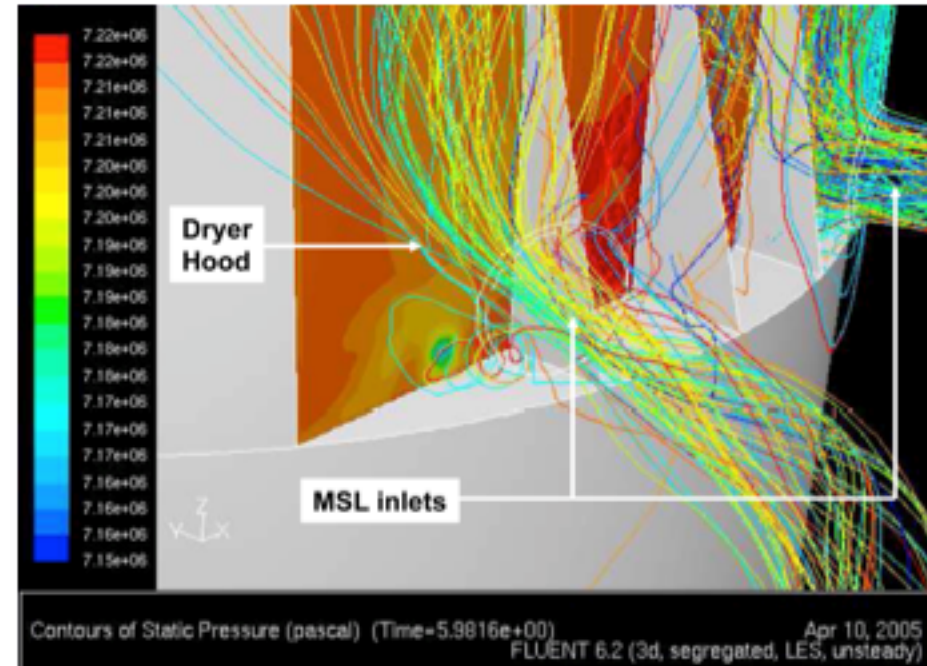
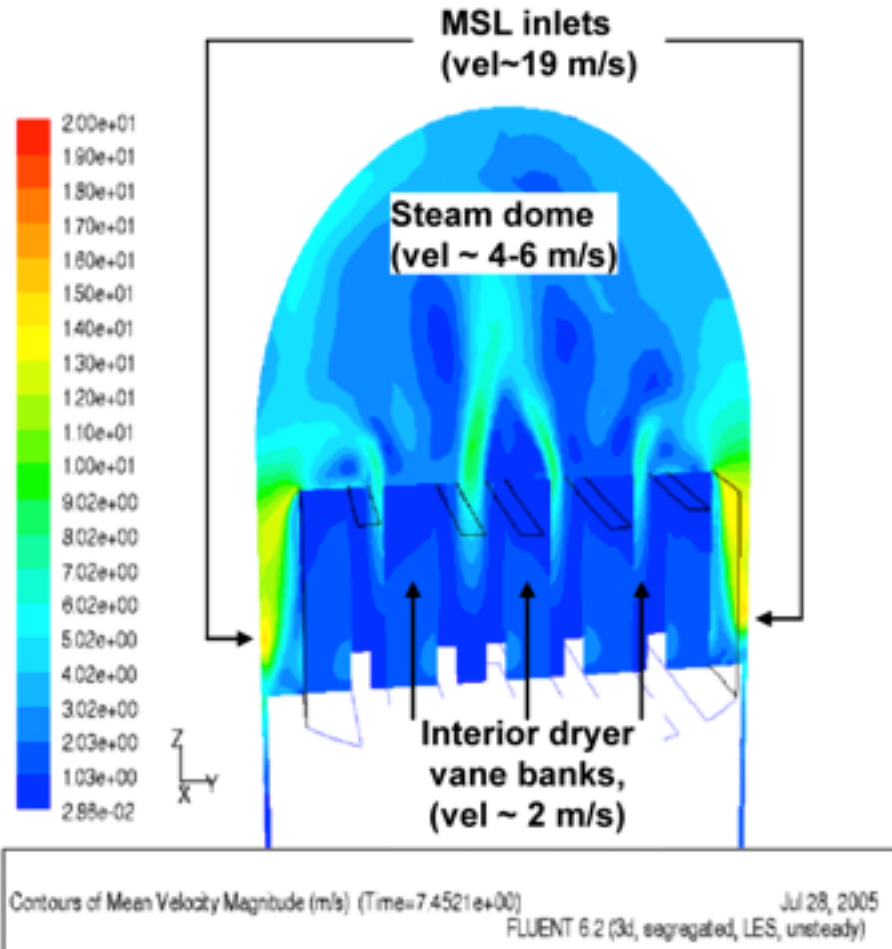
# BWR Steam Dryer FIV and AIV

## Quad Cities Dryer Cracking



# BWR Steam Dryer FIV and AIV

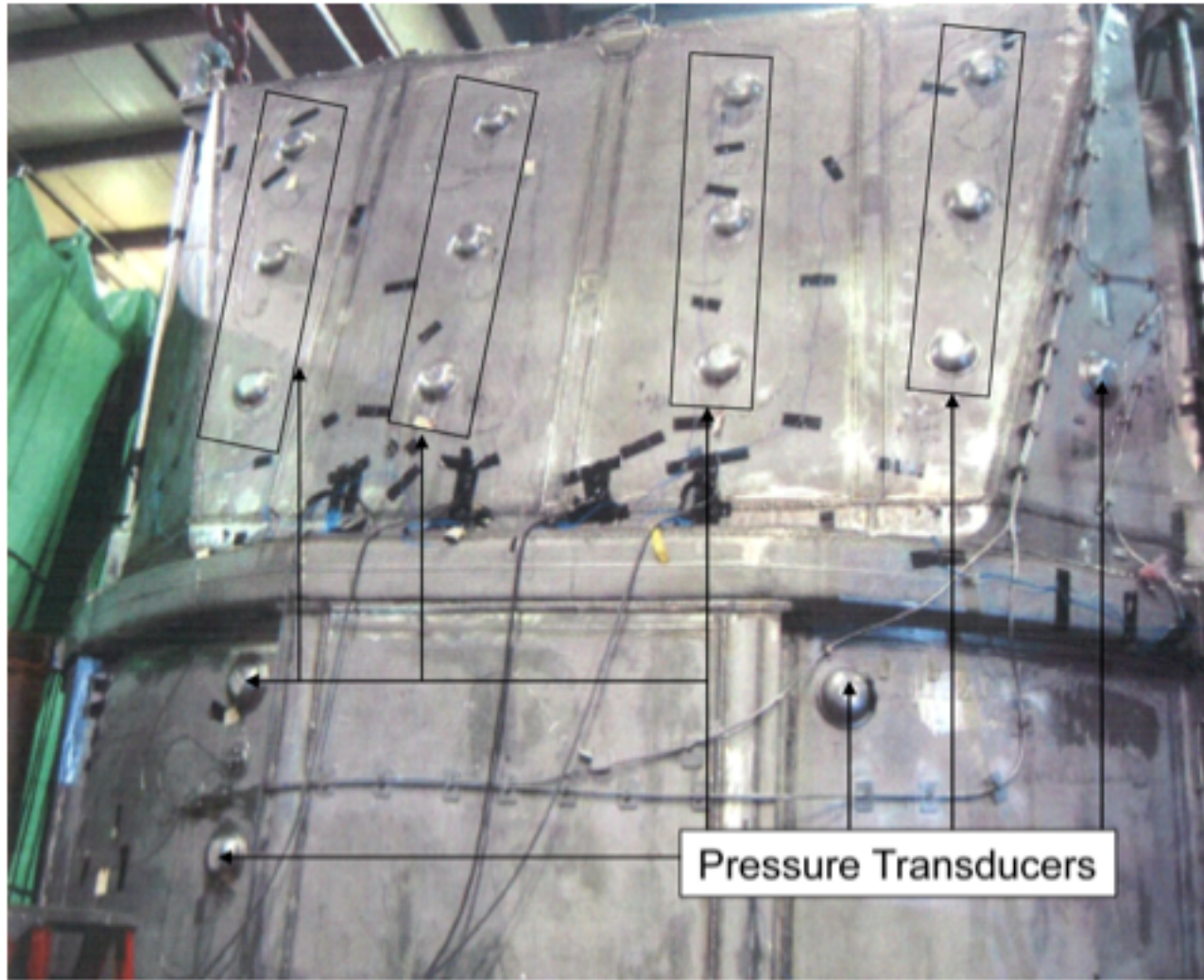
CFD Simulations – slow steam flow,  
no obvious strong sources





# BWR Steam Dryer FIV and AIV

## QC2 Surface Pressure Measurements



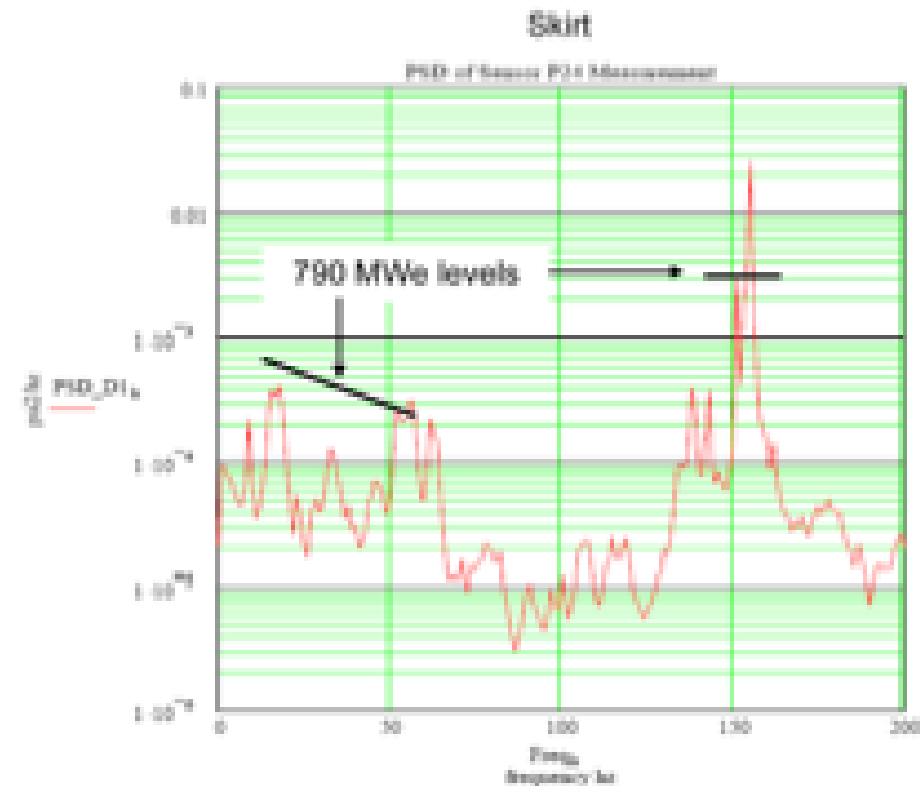
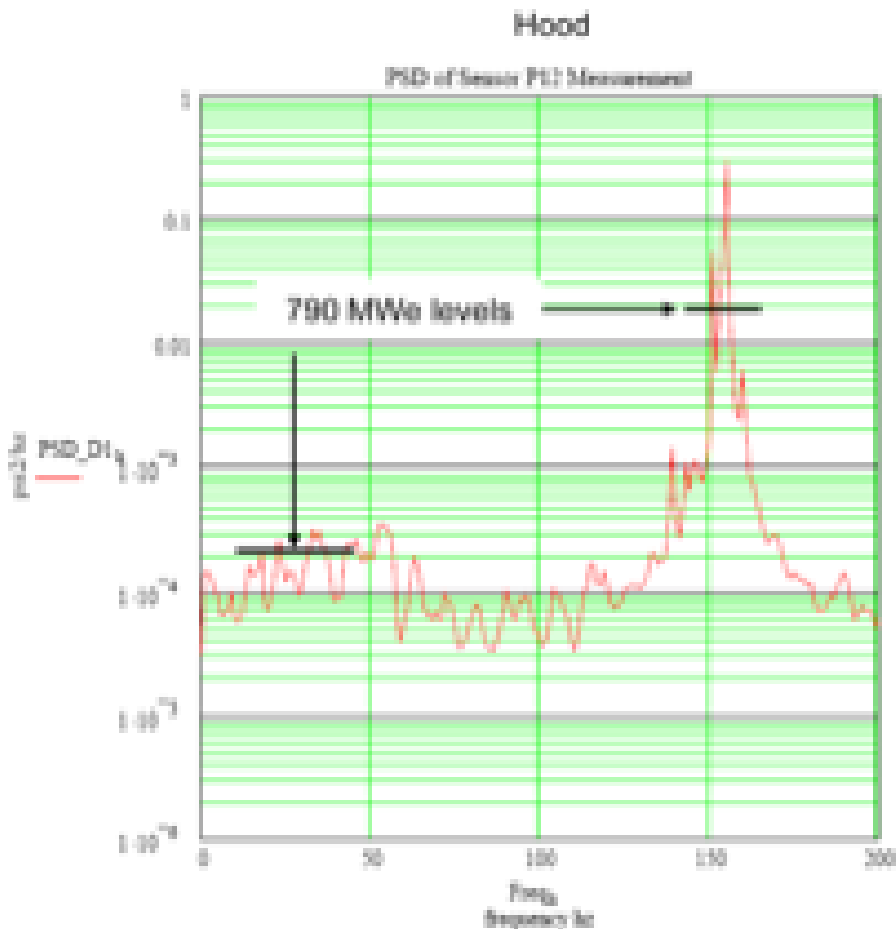
Hood

Pressure Transducers

Skirt

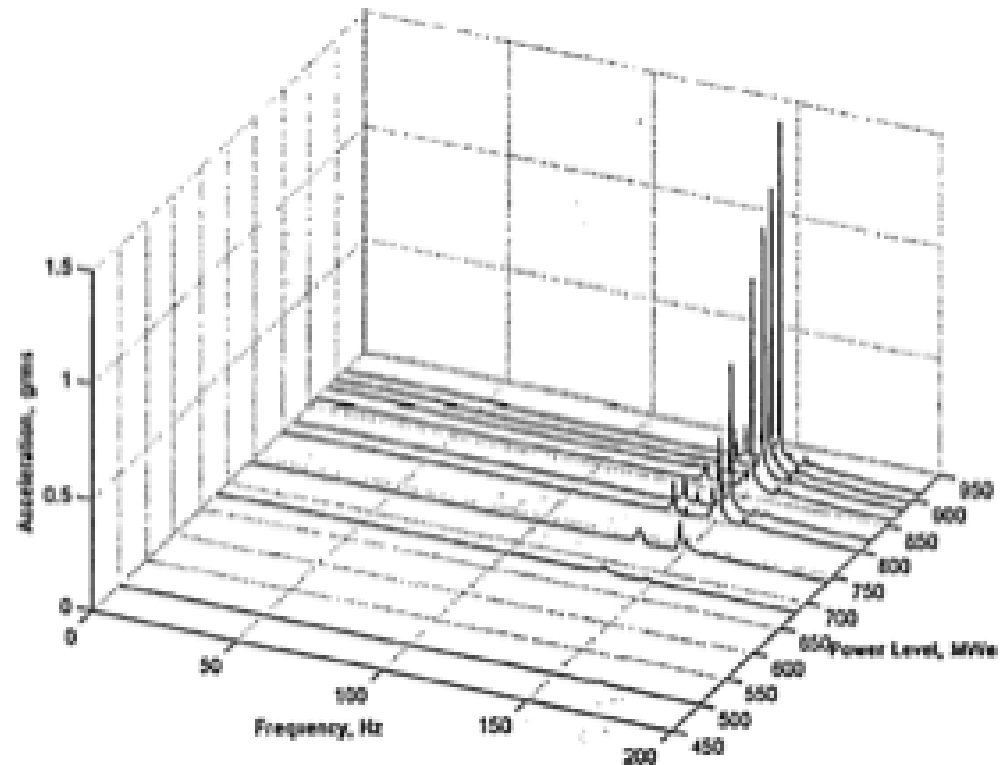
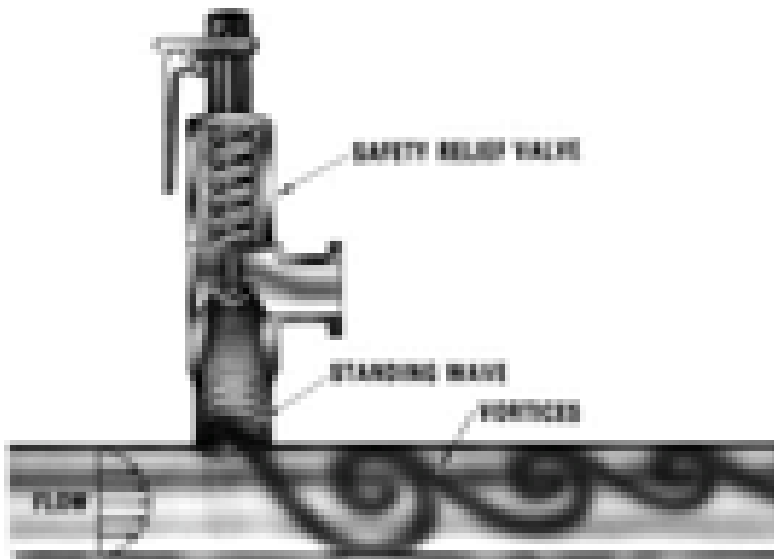
# BWR Steam Dryer FIV and AIV

## SRV Side Branch Resonance Loading



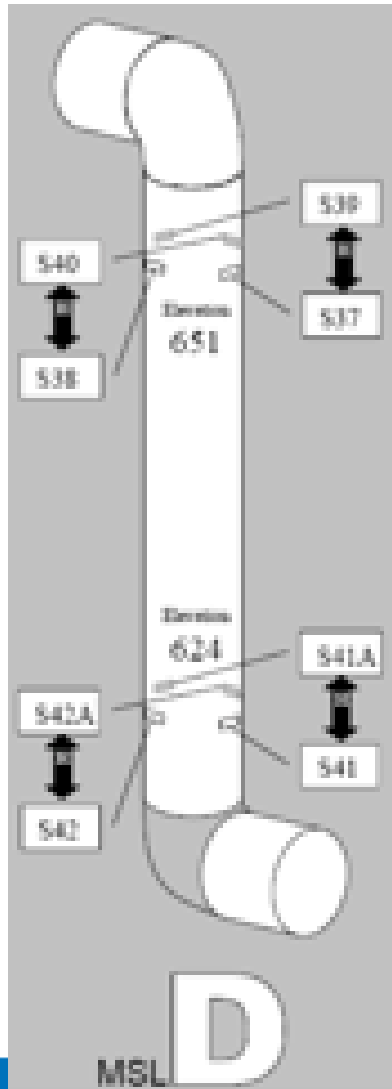
# BWR Steam Dryer FIV and AIV

## SRV Side Branch Resonances

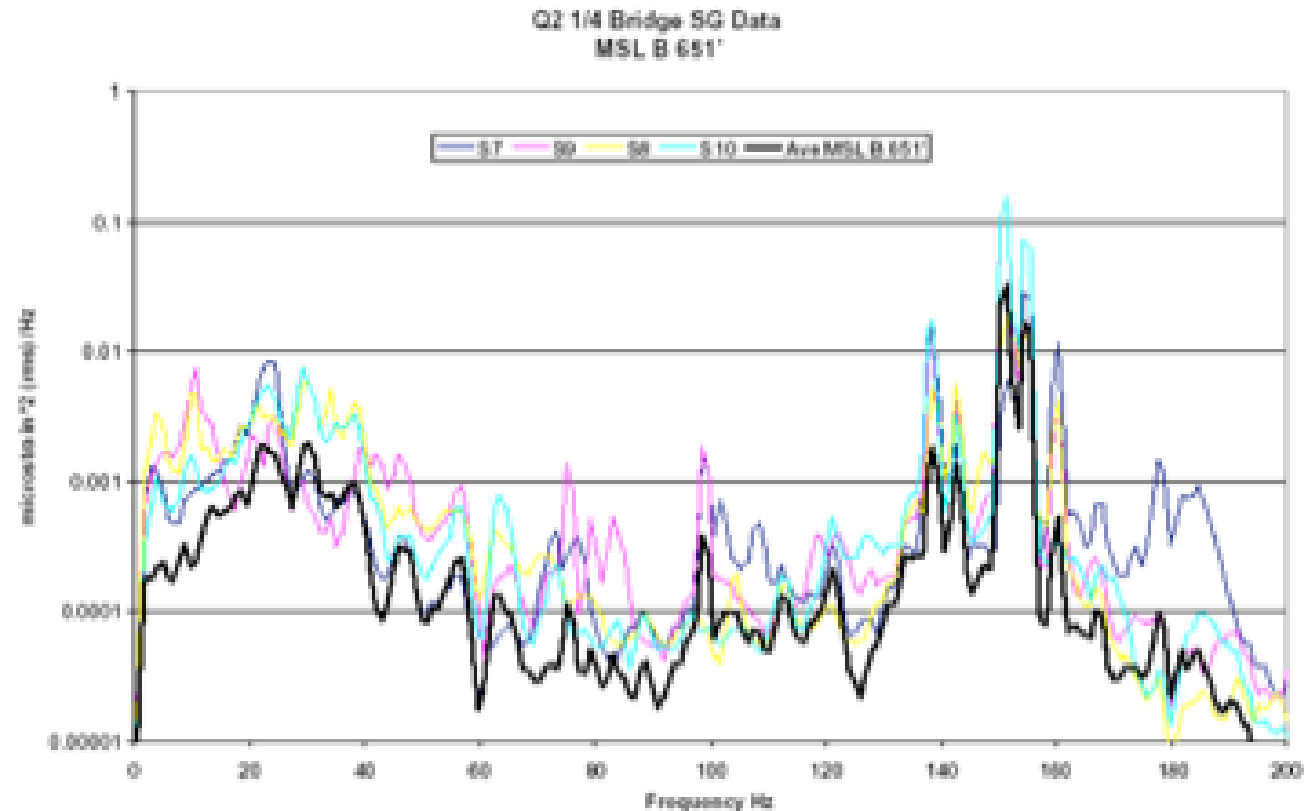


# BWR Steam Dryer FIV and AIV

## MSL Strain Gage Arrays

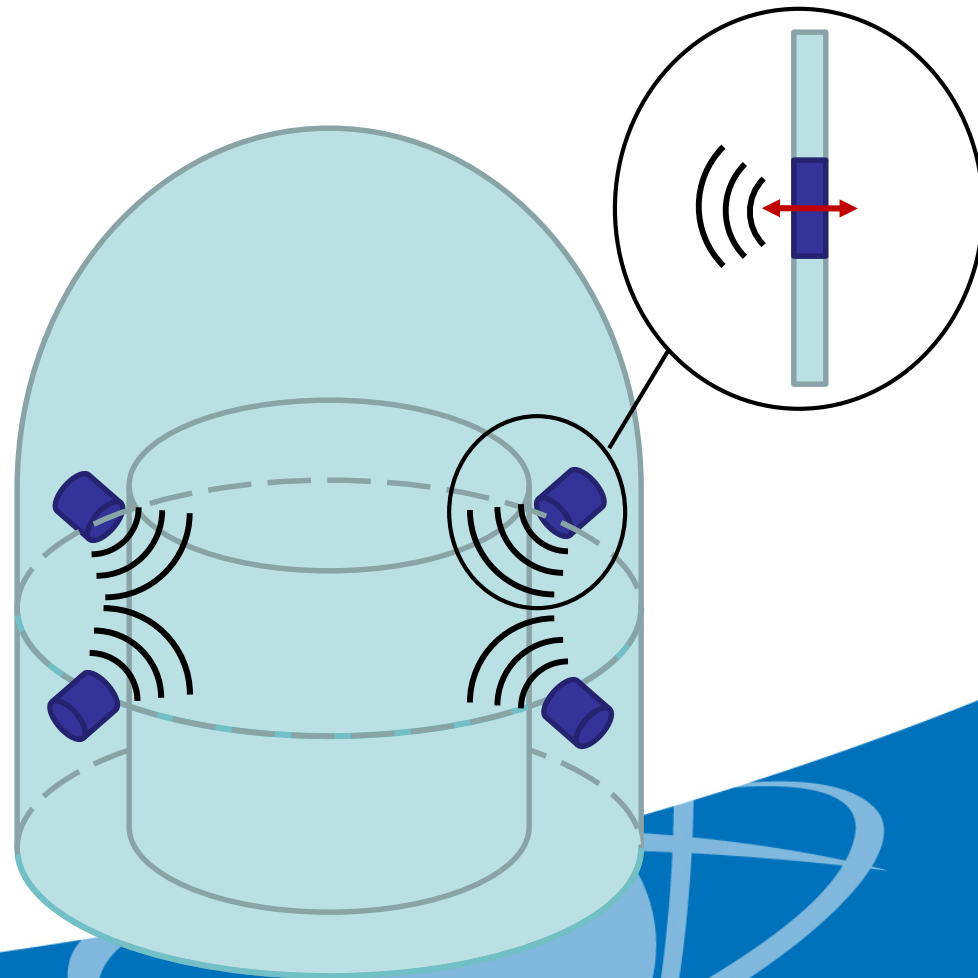


Hoop strain measures internal pressure



# BWR Steam Dryer FIV and AIV

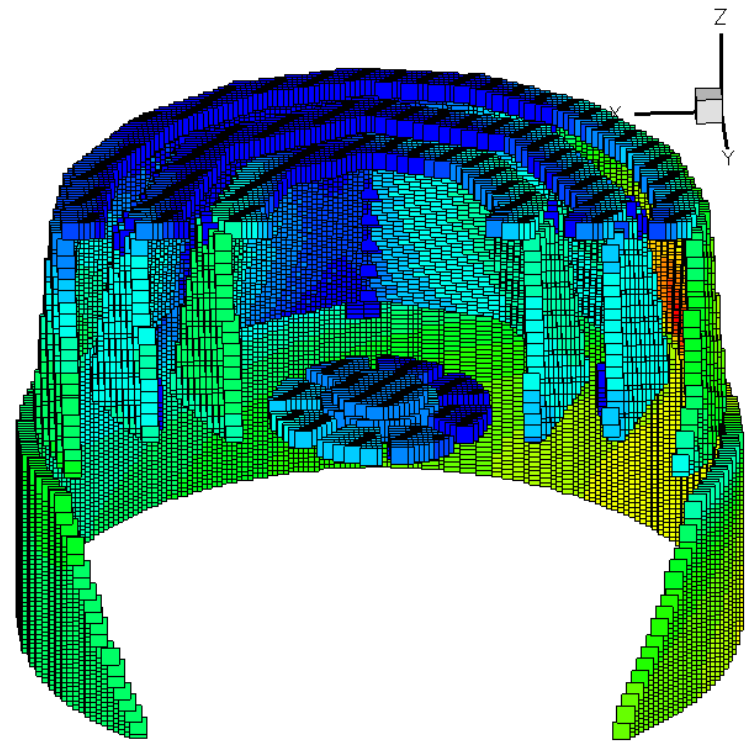
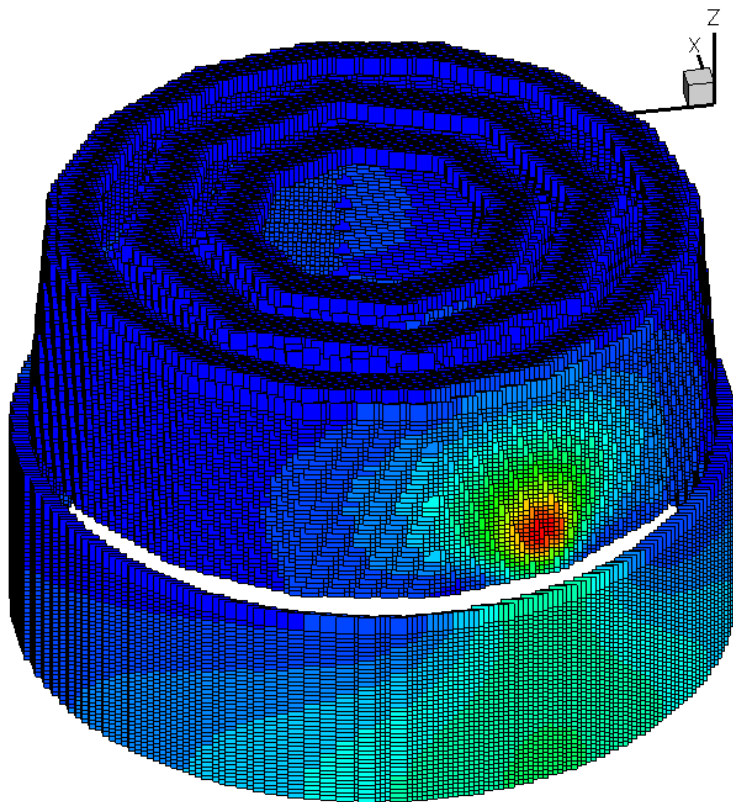
## GEH PBLE01 Dryer Load Modeling





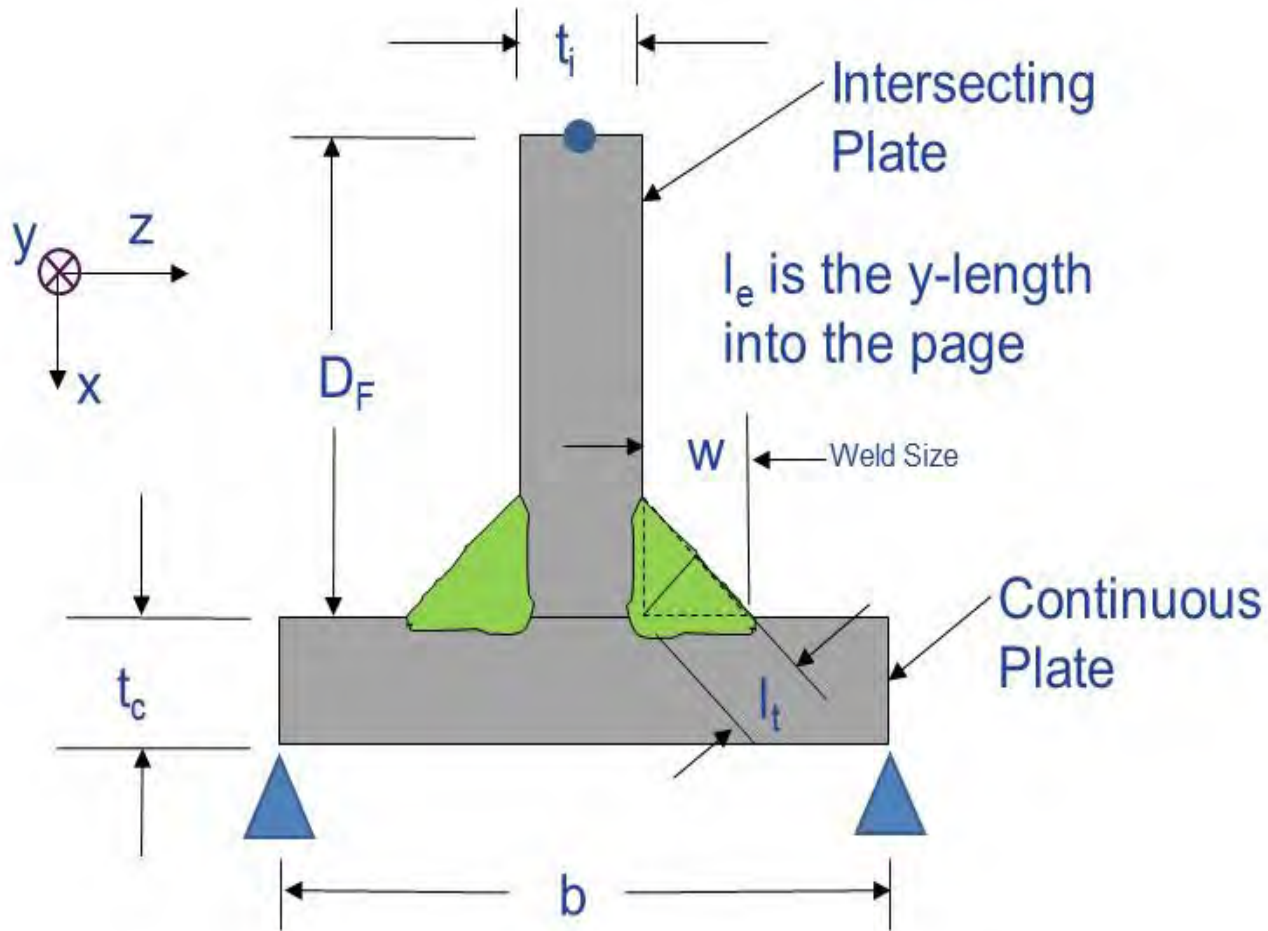
# BWR Steam Dryer FIV and AIV

## Westinghouse Approach: ACE (based on ACM)



# BWR Steam Dryer FIV and AIV

## Weld Stress Calculations



# BWR Steam Dryer FIV and AIV

## Lessons Learned History

- Quad Cities (QC) – Replacement Dryers (RSD)
  - Discovered SRV side branch resonance issue
  - Evaluated GEH and Exelon measurement (MSL strain gage arrays) and modeling (ACM and structural analysis) methods
  - Evaluated benchmarking approaches, primarily of dryer pressure loading
- Vermont Yankee (VY) – Original Dryer
  - Evaluated GEH approximate modeling methods for more efficient power ascension
- Susquehanna (SSES) – RSD
  - Evaluation of RRP VPF mechanical excitation tones
  - End to end benchmarking data (on-dryer strain gages) acquired
    - Learned that industry has difficulty modeling low frequency dryer skirt loading and response

# BWR Steam Dryer FIV and AIV

## Lessons Learned History

- Hope Creek and Nine Mile Point (HC, NMP) - Original dryers
  - Assessed with ACM (CDI), apparent low loading
  - No end-to-end benchmarking
- Grand Gulf (GGNS) - RSD
  - Assessed with PBLE (GEH)
  - End-to-end benchmarking of full replacement dryer
  - Discovered core flow variability has stronger than expected impact on dryer stresses
- Monticello (MNGP) - RSD
  - Assessed with ACE (revision of ACM by Westinghouse)
  - End-to-end benchmarking of upper dryer only
  - Delays and Q/A issues with MSL measurements

# BWR Steam Dryer FIV and AIV

## Lessons Learned History

- GEH ESBWR
  - Designed with PBLE
  - Multi-plant prototype and non-prototype procedures established
- Peach Bottom (PB) - RSDs
  - Assessed with ACE
  - End-to-end benchmarking led to on-dryer stress estimates which exceeded allowable fatigue limits
    - Inference method developed based on FE mode shapes and on-dryer strain measurements
- Nine Mile Point and Hope Creek redux
  - ACM errors discovered by Westinghouse while evaluating MNGP and PB (skirt loads much too low, leading to non-conservative lower dryer stress estimates)
  - NMP2 assessment of impact of errors ongoing

# BWR Steam Dryer FIV and AIV

## Lessons Learned History

- Browns Ferry (BFN) – RSDs
  - Original EPU application attempted to qualify existing dryers
  - Electrical and other background noise corrupted MSL measurements
  - Could not establish existing dryer safety with reasonable assurance
  - New 2015/16 application provides improved MSL measurements
  - RSDs will be used with end-to-end benchmarking

# BWR Steam Dryer FIV and AIV

## Lessons Learned History

Plant	Plant Design/ Containment	Original License	EPU granted	RPV I.D. (in)	OLTP Power (MWt)	EPU Power (MWt)	OLTP MSL Steam Velocity (ft/sec)	EPU MSL Steam Velocity (ft/sec)
Monticello (MNGP)	BWR3/Mark I	1971	2014	205	1670	1870	149	179
Quad Cities 1/2 (QC)	BWR3/Mark I	1972	2004	251	2511	2957	168	202
Dresden 2/3	BWR3/Mark I	1970	2004	251	2527	2957	168	202
Vermont Yankee (VY)	BWR4/Mark I	1972	2006	205	1593	1912	140	168
Browns Ferry 1,2,3 (BFN)	BWR4/Mark I	1973	Pending	251	3293	3952	128	161
Susquehanna 1,2 (SSES)	BWR4/Mark II	1983/1985	2009	251	3293	3952	128	158
Hope Creek (HCGS)	BWR4/Mark I	1986	2008?	251	3293	3840	143	167
Peach Bottom 2,3 (PBAPS)	BWR4/Mark I	1973	2014	251	3293	3951	129	155
Laguna Verde 1,2 (LV)	BWR5/Mark II	1990/1995	2014/2015	205	1939	2327		
Nine Mile Point (NMP2)	BWR5/Mark II	1987	2011	251	3233	3988	143	177
Grand Gulf (GGNS)	BWR6/Mark III	1984	2012	251	3833	4408	139	163



# BWR Steam Dryer FIV and AIV

## Lessons Learned History

Plant	Original Steam Dryer type	FIV MSL tones	MSL ASBs installed	Dryer loading tool	Dryer structural analysis tool	Modifications/ Replacement
Monticello (MNGP)	GE Square hood	Yes, ...	No	ACE	Westinghouse frequency domain	Replaced with Westinghouse 3 ring octagonal 'Nordic' dryer
Quad Cities 1/2 (QC)	GE Square hood	Yes, primary shear layer	Yes	ACM	GE time-domain	Replaced with GE stiffened slanted hood (QC2 dryer instrumented), ASBs installed
Dresden 2/3	GE Square hood	Yes, primary shear layer	Yes	ACM	GE time-domain	Replaced with GE stiffened slanted hood, ASBs installed
Vermont Yankee (VY)	GE Square hood	No	No	ACM	GE time-domain	Modified original dryer
Browns Ferry 1,2,3 (BFN)	GE Slanted hood	Yes, primary shear layer, and deadleg low frequency	No	PBLE	GE time-domain	Replaced with GE stiffened curved hood, BFN? Instrumented
Susquehanna 1,2 (SSES)	GE Curved hood	Yes, secondary shear layer, and deadleg low frequency	No	ACM	GE time-domain	Replaced with GE stiffened curved hood, instrumented
Hope Creek (HCGS)	GE Curved hood	No	No	ACM	CDI frequency domain	Modified original dryer, in-air damping measured on spare HC original dryer
Peach Bottom 2,3 (PBAPS)	GE Curved hood	Yes, primary and secondary shear layer	No	ACE	Westinghouse frequency domain	Replaced with Westinghouse 3 ring octagonal 'Nordic' dryer
Laguna Verde 1,2 (LV)	GE Curved hood	Yes, primary shear layer	Yes	ACE	Westinghouse frequency domain	Modified original dryers
Nine Mile Point (NMP2)	GE Curved hood	No	No	ACM	CDI frequency domain	Modified original dryer following discovery of nonconservative dryer loading errors
Grand Gulf (GGNS)	GE Curved hood	Yes, secondary shear layer	No	PBLE	GE time-domain	Replaced with GE stiffened curved hood, instrumented